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Burnt Offerings

ARTICLE BY BILL NORTON

Burnt Offerings

ARTICLE BY BILL NORTON



Few fantasy creatures have the popular appeal of dragons. Centuries of mythology offer ample evidence that this fascination is far from new. What is new are the dynamic methodologies used to depict these winged reptiles in motion pictures. The desire to create the ultimate dragon — and the ultimate ‘dragon movie’ — was the impetus behind *Reign of Fire*. Armed with the latest in digital firepower, director Rob Bowman challenged his visual effects team to produce a dragon so photoreal and believable as to rank among the most frightening of movie monsters.

Reign of Fire begins with a schoolboy, Quinn Abercromby, who ventures into a cavern unearthed by construction workers extending the London Underground. There he unwittingly disturbs an ancient fire-breathing dragon, and the subsequent deadly encounter between beast and humans leaves the boy permanently traumatized. Freed from its imprisonment, the dragon breeds to more than a million in a year. Twenty years later, civilization has been laid waste by the relentless predators, who have burned and eaten most organic life on earth. The appearance of a band of American militiamen with cobbled-together high-tech weapons ultimately motivates the now-grown Quinn to face his fears and confront the original bull dragon in a fight that will determine the fate of humankind.

Rob Bowman, a veteran of such television series as *Star Trek: The Next Generation* and *The X-Files*, as well as *The X-Files* feature film, had never worked on a visual effects show of such complexity — particularly one whose antagonist would have to be computer generated. For assistance, Bowman and Spyglass Entertainment producers Gary Barber and Roger Birnbaum turned to Walt Disney Studios’ in-house effects unit, The Secret Lab, to bring *Reign of Fire*’s celluloid dragons to life.

Bowman’s two-year stint on the project began in June 2000 with his undertaking a major script overhaul that would continue well into principal photography. “The original screenplay wasn’t what I wanted to make,” Bowman recalled, “and it was probably a \$200 million film — which was too darn much money. But the central idea was very compelling. I knew I’d have to adjust the tone and scope of the movie and boil it down to its essence. There was just too much in it; and tonally, it was a little sillier than I wanted to make it.”

An unusually short preproduction due to a threatened writer's strike meant that the design and development of the CG dragons — which normally would have progressed from drawings and sculptures to scanned maquettes to CG modeling and refinement — could not be accommodated. "We didn't have enough time for the classic pipeline," explained Richard Hoover, who shared visual effects supervisor duties at The Secret Lab with Dan DeLeeuw, "so we went at everything at the same time. Rob brought in outside storyboard artists — Matt Codd was the lead artist for that group, doing a lot of conceptual art and design work — as well as some physical sculptors, under Miles Teves, who were working in clay, just sculpting ideas. Simultaneously, we had our own digital sculptors and 3D modelers working on designs and building the digital model, with Mike Meaker and Allen Battino from our art department producing extensive concept art. It was a creative workshop where everyone looked at what everyone else was doing — the modelers looked at what the 3D sculptors were doing, the 3D sculptors looked at what the artists were doing, and it went around and around until we finally got something Rob was happy with. Because we had to go to CG right away, we debated whether it was really necessary to do physical models; but I felt that having something tactile that everyone could see and touch, from executives on down to the artists, was important. In the end, once the physical sculpture was approved, we scanned that in and manipulated our CG models to match."

Despite the time constraints, the intensive design process would extend over nine months, overlapping the start of shooting by about two. "We had to determine the look, the physics, the physiology, the anatomy, the personality of the dragons," explained Bowman, "plus all the infinitesimal design aspects. I was very specific about what I wanted; and the result was that we came up with a dragon that was unlike anything from any other movie."

For ideas on dragon Evolution, anatomy and locomotion, the design team studied classic depictions of dragons and observed real animal behavior. "We did a lot of homework on the mythology and all the renderings of dragons that have been done," commented Hoover. "We looked at hundreds of comic book, Chinese and historical mythological drawings. A lot of them had humanistic qualities, but Rob wanted to stay away from that." Since Bowman's mandate was to create a believable creature that might have actually lived, the team also consulted with a paleontologist and gathered ideas from books, nature documentaries and visits to the Los Angeles Zoo.

Guided by Dan DeLeeuw, the team's avowed creature specialist, the dragon design went through numerous iterations that incorporated a variety of animal traits and behaviors. "One of Rob's goals was that the dragon look reptilian," DeLeeuw explained, "but we didn't want it to look like a dinosaur. So when the early designs came back with big strong jaws, like a T-rex, we went back and slimmed those down and made them look more snaky." As an aid to conceptualization, DeLeeuw drew up a hypothetical history of the dragons that included their character and how they might have evolved. "Basically, they are at the top of the food chain now, and there's nothing humans can do against them. Everything about them is a weapon. They're fighters — lean and very strong, with very little body fat. They're the perfect predators."

Aggressive character traits would be infused into every aspect of the creatures, from their horned heads, claws and spiked tails to their coloring and the look of their wings. “I theorized that the dragons were always battling each other or the forces trying to eliminate them,” explained DeLeeuw. “So when we designed and painted the texture maps for the wings we added bite marks and made a bunch of holes to represent machine gun strafes. Once we got through with the damage on the wings, we went back in and made the dragon look as mean as we possibly could. And the more scarred and damaged it was, the meaner it looked. We suggested the dragon’s history through its scars.”

To avoid the hard, leathery look of dinosaurs and emphasize the reptilian connection, DeLeeuw insisted that scales cover the creatures — a major challenge for the CG modeling team. “Dan didn’t want displacement maps for the scales,” said digital effects supervisor John Murrah. “In case we had closeup shots, he wanted to see the scales move realistically, riding on top of one another, with just the skin between them stretching and not the scales themselves.”

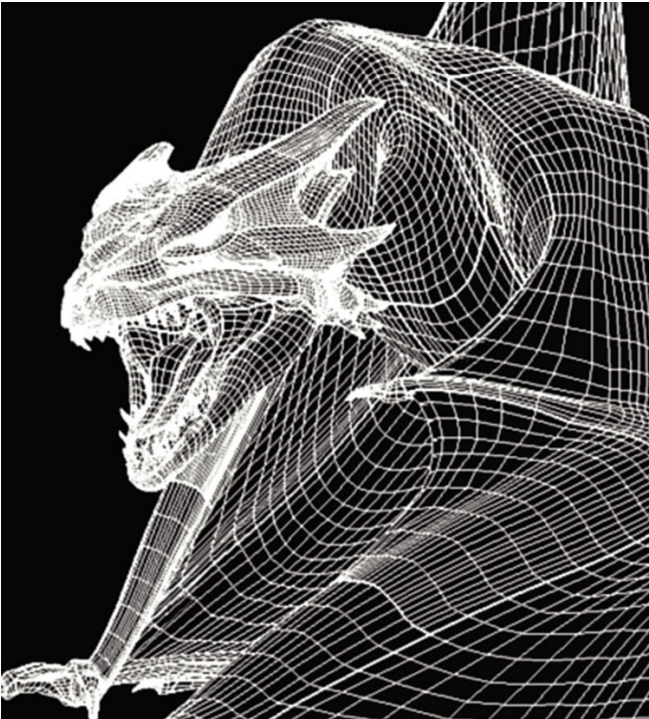
The Secret Lab ultimately solved the problem by expanding the capabilities of its proprietary hair renderer to grow scales instead of fur. The tool was used to tile the dragon’s surface with thousands of individual 3D scales that overlapped and could move relative to one another for a serpentine feel, or pull apart to reveal the fatty flesh layer underneath. “It was Hank Driskill’s idea to change the fur system we had developed for Dalmatians in order to grow the scales,” CG supervisor Adolph Lusinsky revealed. “The first test was to grow scales on some dog animation we had. It looked like corn-on-the-cob, but it told us we were on the right track. At first we were going to make the skin like a snake’s; but snake scales are shiny — which made the dragon look like a plastic toy — and the herringbone pattern blew the dragon’s scale. So next, we rented crocodile and alligator pelts and photographed different scales. For example, those that went along the arm, where the animal needed to bend, tended to be more pebbly than the armored scales on the back. We actually took a lot of those references and put them right onto our dragon, which got us fifty percent there. They were all modeled as displaced NURBS.” Though the hair renderer proved ideal for tiling the dragon body with scales, modelers ended up painting displacement maps on the dragon’s head in order to reach all the nooks and crannies. To avoid the stretching problem, Rob Falco wrote a shader for the displacement maps so that when the skin on the head was stretched, the scales maintained their original shape.

Perhaps the most intriguing aspect of the dragons was their flaming breath. Though the real world had no known parallels for fire breathing, nature did provide a reasonable facsimile. “Our art director, Mike Meaker, had seen an African beetle with a similar defense mechanism,” said



Aroused after untold centuries of sleep, fire-breathing dragons overrun earth and nearly reduce civilization to cinders but for a band of determined survivors in *Reign of Fire*. Director Rob Bowman instructed artists at The Secret Lab – under visual effects supervisor Richard Hoover – to create the fully-CG beasts as if they were real animals that had evolved through natural selection, basing their appearance and behavior on existing predatory animals and birds.

DeLeeuw. "It sprayed a chemical out its rear and made sparks to ignite the stream. So our idea was that there are two glands at the back of the dragon's throat, producing chemicals. The dragon spits out the liquids with muscles constricting on the glands. When the two streams cross fifteen or twenty feet in front of the dragon they naturally combust." For the spitting action, animators suggested that the dragon draw back and shake its head before thrusting forward, a behavior borrowed from spitting cobras. "We also wondered what would happen if, whenever the dragon got ready to breathe fire, it drooled from either side of its mouth like a dog. As this fluorescent blue fluid drips together, it sparks and burns as a cool blue flame. So, we had the dragons actually drooling fire." Practical drool and small fire elements were shot at the company's Stagg Street stage in Sun Valley and tracked onto the digital dragon, as needed. A combustible blue liquid stood in for the drool, flowing from a remote-controlled device built by John Gray of Reelistic FX who, in addition to the drool, contributed many of the other practical fire elements composited into effects shots.



Advanced skin and muscles systems incorporated into the CG dragons enabled animators to concentrate on performance while still achieving subtle wing dynamics and realistic movement of skin and muscles. Thousands of tiny reptilian scales were achieved with a hair renderer reengineered to produce scales instead of fur. The fully rendered dragon was composited into digital and live-action environments enhanced with CG smoke, ash and flame.

Integral to the task of developing the physical characteristics of the dragons was determining how they would move, both on the ground and in the air. This was no simple task given the creatures' enormous sizes and wingspans — females were conceived as 160 feet long with a 240-foot wingspan, and the patriarch 'bull' dragon was 180 feet long with a 320-foot wingspan, or roughly the size of a 747 jumbo jet. The giant wings had been designed like those of a bat, with the fingers spread out to support them. A long bone at the wrist extended back, with the fingers coming off further down the arm. "It wasn't like animating a dog or a cat, where you just have four legs," observed DeLeeuw. "The dragon's back legs were just there to help hold up the hips, while its weight was really supported on the wings. The arms were a combination of arms and wings; so as the creature moved around, we'd have another 140 to 160 feet of wing hanging off the wrist." When the wings were folded on the ground, the fingers supporting them bent up behind the creature, creating scalloped edges for a wicked silhouette shape — particularly dramatic when the dragon was backlit, as was often the case.

To free the animators from having to hand-animate subtle wing dynamics on top of the broader wing movements, creature supervisor Rob Dressel and the software team built a dynamic wing membrane system into the existing skin and muscle system. During rendering, the dynamics would take over and create detailed movement within the flaps — such as fluttering and stretching of the wing membrane. "If the 'fingers' were far apart or close together," explained Dressel, "we could make that membrane as tight or as droopy as we wanted. Once we got the software working, we saw really subtle movement that just blew away what anyone could do by hand. It was also art-directable, so you could set the material style as far as how it bounced and jiggled. Those and other controls made the dragon the most complex animation rig I've ever worked on."



Dragon concept consultant Matt Codd and sculpting supervisor Miles Teves detail a head maquette of the fearsome bull dragon. The sculpt was one of many physical prototypes produced by a team of sculptors and artists working in concert with the director and the digital crew to establish the look, physiology and behavior of the dragons. Approved maquettes were scanned by the digital team to aid in the construction of the CG animation model.

For ideas on how the dragons should ambulate, animators once again turned to the natural world. “We used predatory birds for behavioral reference,” said Richard Hoover. “Those were best for determining how the dragons should land, how they should attack something from the air, how they should fly out — those kinds of things. Once a dragon was on the ground, it became much more reptilian in its behavior, which was just more wicked-looking. Rob’s sound design guy had recorded a cobra in a trash can striking at the microphone; and once we heard that, it gave us ideas about what the mouth and neck and head attitude should be, and we carried that behavior through the body.”

Ground locomotion for the dragons was also influenced by the desire to avoid the dinosaur motif. “The first animations we did were very ‘dinosaury’ — big and lumbering,” DeLeeuw related, “with too much of a T-rex step pounding the feet into the ground. Then I got a tape of Komodo dragons and looked at how they moved. It was much more snaky, slithering on the ground; so we started thinking about that, and finally hit on a solution after looking at a couple of nature tapes of big cats hunting. In those tapes was a shot of a leopard slinking through the tall grass in a really cool pose where the shoulders came up high, and the legs were going forward and back, very much in line with the body — very feline. When we incorporated that with a snaky movement in the dragon’s long neck, the combination was something no one had ever seen before — but the separate movements resonated as familiar-looking.”

Distinctive walk cycles underscored the creature’s sinister, predatory character. “We were having a hard time coming up with what Rob wanted,” recalled Mike Meaker. “Then one day, he said: ‘Just think of it as Bela Lugosi.’ He got down on all fours and started crawling on his forearms, putting his hands in front of his face. From that we made a walk cycle where the dragon draws its arms and wings across its body, giving it a shrouded, mysterious look.” The wing-enclosed posture also served to conceal the beast’s slender legs, the design of which had not been a complete success. During flight the legs were scrupulously tucked up within the dragon’s body.

While a frenzy of design work, modeling and animation tests was underway at The Secret Lab, principal photography on *Reign of Fire* commenced in late January 2001 at Ardmore Studios in Bray, Ireland, just outside Dublin. Because of the compressed shooting schedule, Bowman eschewed the use of motion control, greenscreen setups or interactive effects on the sets. “I did not have time to set up greenscreens,” Bowman recalled. “I told Richard that I needed the freedom to shoot the movie so that it felt less dramatized and more documented. I wanted the energy of a fast shoot. I wanted to get my shots off quickly so the actors were keyed up. I just shot hand-held and on a Steadicam on scooters,



For a scene in which one of the creatures is felled by a harpoon, Artem was commissioned to build a full-size practical dragon that performers could interact with during live-action photography. To ensure a precise replication of the CG dragons, Artem crew members scanned a maquette of the

running and grabbing dragon plates here and there. Richard's confidence in being able to work with it later made that possible."

"It was a difficult picture to shoot," Hoover added.

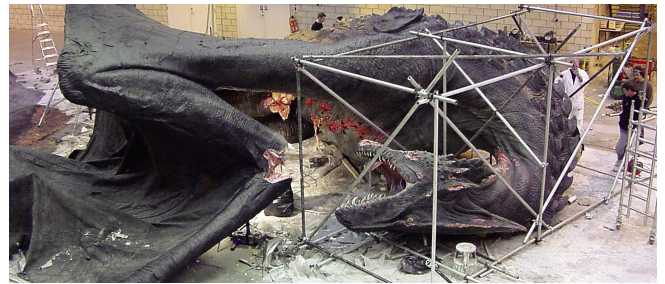
"Traditionally in this type of movie, you try to help the actors with eye-lines and give them some sense of the scale of the creatures, because they're trying to act to something that's not there. All kinds of tools have been used in the past to help in that regard — eyes on a pole that you walk through a scene, or blow-up dolls that resemble the scale magnitude of the CG character, so the DP has some idea how to light it. But these dragons were huge, so blow-up dolls didn't really work. And they were going to be flying very fast and covering a huge amount of distance, so there was no way eyes on a stick would work. There were a lot more elaborate things we could have come up with to simulate the creatures; but in the end, the speed at which we were shooting didn't allow for that."

Since there were almost no motion control setups, a fast and effective means of surveying sets was needed that would allow the digital team to re-create environments in the virtual world. "We developed a pretty robust tracking system using surveying and some cool marker tools," Hoover said, "to the point where, when I came back, I had so much information that I could reconstruct any set. Before shooting, we pre-wired the sets with hundreds of tiny radio-controlled LED lights, powered by portable battery packs that could be recharged at night and plugged in in the morning. I could sit right next to the camera, flip a switch and they would all come on. Shoot the shot, flip the switch, and they'd all go off. Then I'd have the survey guys someplace else surveying points while we were doing the plate photography. So by the time production called 'wrap,' we were either already done or about done. It made life a lot easier for production, and allowed us to get all the data we needed without having any surprises later." Back at The Secret Lab, the survey data and LEDs in the plates were run through a program called Rastrack in order to derive the original camera's motion to establish the virtual camera move for the CG dragon and other animation. The LEDs were subsequently painted out.

With up to five cameras shooting simultaneously, not every scene had LEDs. In shots where the LEDs were not present, The Secret Lab applied a technique known as photogrammetry, which made use of a series of photographs taken from several angles to re-create a three-dimensional version of the set.

Lighting the CG dragons to match the plate photography presented considerable challenges, given the dark and gloomy nature of the show's environments. Though film negative can

downed beast sculpted in the appropriate pose, and referenced data files supplied by The Secret Lab prior to building. Sculptor Steve Jolley adds detail to the dragon head.



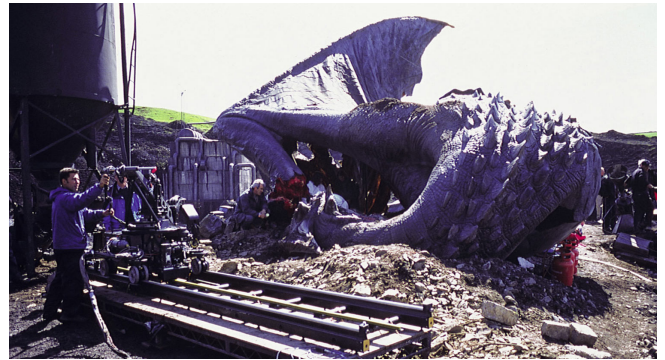
The massive dragon prop under construction in London. Artem crew members built everything but the tail and one wing, which were to be computer generated inpost, meticulously matching the color scheme to that of the digital dragon. The team had just ten weeks in which to complete the assignment before hauling the massive replica - designed to foldup for convenient transport - to southern Ireland where principal photography was underway.

capture a great range of lighting information, detail is lost in the print so that dim objects become darker or black, and bright areas grow brighter or white. The same effect occurs in scanning the negative to the computer's binary format, with the selection of high- and low-end f-stops possibly causing information to be dropped. This could make the dragon appear as little more than a silhouette, and its fire breath no more than a white flare. To combat the problem, compositors employed high dynamic range lighting data — used to create a map of lighting values from every part of a set — plus additional techniques that allowed them to render and composite at desired f-stops with richer detail.

"When Rich went out to Ireland," Adolph Lusinsky recalled, "we had him take wide-angle fisheye lenses and shoot HDR images of all the sets from different angles. For the dragon, we mixed that data with a 'faux radiosity' shadow pass using Entropy. From any point on an animated surface we'd shoot out a ray and see how many objects it hit. The more objects that got hit, the more hidden that surface was and the blacker it got. The less the ray-tracer hit, the whiter it got. So we were able to get really nice, soft shadowing in all the areas traditionally hard to get in CG."

Since overcast skies were a predominant motif in the film, and using just the HDR images to illuminate would have resulted in a dragon that looked flatly lit, extra lights were added to create the specular kicks and rim-lighting that Bowman desired. "In Dalmatians," related Lusinsky, "a typical shot would take seven to nine lights to get it to fall off correctly and feel like there was light bouncing off the walls. With this, aside from any added firelights, most of the shots were lit with just three lights. It made the lighting pipeline much smoother." The naturally camouflaged dragon, seen against a dark sky or ash-covered ground, also benefited from a moderate sheen to its scales that exaggerated the specularity for a more dynamic look.

The sheer size of the dragon also had to be accounted for in marrying the digital and live-action elements. "The biggest challenge was the fact that we had a character that was so large," explained compositing supervisor Blaine Kennison. "In trying to simulate the dragon being in a 3D environment, we had to do a lot of things that we don't normally do. For example, we can usually layer things without running into problems like severe depth of field, because they happen in a very finite space. But if the dragon was completely in frame, it became a wide-depth background. We had to worry about things that told you how close something was, like going from sharp in front to blurry in the background, from being more contrasty in the foreground to more hazy in back. We also had to sell a dragon in flight covering great distances, going from hazy to clear as it got closer to camera. So we sometimes had to split the dragon into portions, depending on what effects were happening around it. We developed a couple of macros, including our fog shader, which allowed us to add atmospheric perspective to the



An eight-person Artem crew assembled the full-scale model on location. To make it appear as if the creature, though mortally wounded, was still somewhat alive, puppeteers concealed inside the body articulated the dragon from within, dribbling slime from its open mouth and simulating breathing through pneumatics installed in the torso.

dragon. We called it 'z-depth compositing.' We also had to do things like add heavy blur if the plate wasn't very sharp. The dragons were never still, and the camera was usually moving; so we ended up taking away some of the detail that the animators worked so hard to add in. But if the detail wasn't there to begin with, it would have looked like mush when we blurred it."

Another challenge in integrating the digital dragons with the live and CG environments was creating believable interaction between the creatures and enveloping atmospheric effects. "We had all these environmental effects to contend with, since everything is on fire," Dan DeLeeuw stated. "One thing CG likes is nice clean backgrounds; and here was this diffuse environment with smoke all over it. So we had to come up with ways to get around that — and not only did it have to look real, it had to be fairly economical to do."

Besides fire and smoke, atmospheric effects included blowing embers and ash stirred up by the dragons' footfalls and flapping wings — all mixed with an ever-present, ethereal fog from which the winged beasts typically emerged. Integration of the CG dragons with this mix of airborne particles called for a strategy that would allow the digital team a high degree of manipulation. "We knew that the current available particle renderers weren't going to accomplish what we wanted," said John Murrah, "specifically, the really detailed displacement around the individual particles that you get when you have an object fly through, or the individual tendrils of wispy fog that dissipate as it starts to evaporate."

Seeking an alternative approach, technical supervisor Hank Driskill assembled a four-man team — Chyuan Huang, Patrick Dalton, Rob Rosenblum and Lawrence Lee — to explore computational fluid dynamics, a tool employed by the aerospace industry for simulating the motion of a gas or a liquid and its interaction with bodies immersed in the flow. More than a traditional particle simulation in which particles bounce off a discrete collision object, CFD uses voxels — a 3D array of data values that approximate the distribution of features such as velocity and temperature within an assigned volume. "In the general flow of work," said supervising effects animator Chyuan Huang, "we'd get the digital character or prop animation and maybe digital sets, and we would 'voxelize' them into a discrete volume in space to simplify the calculations. Our input parameters to the CFD engine were the motion, such as the dragon landing, the initial airflow and, optionally, temperature. The output was a velocity field which said, at each time step, what the airflow would be at every point. We chose the volumes to maximize the detail we needed. Once we had that, we sent particles through the velocity field, and determined what kind of rendering attributes to put on the particles. The particles were then rendered through our 3D volumetric renderer, Jig."



A parachutist — one of a team of 'archangels' commanded by dragonslayer Denton Van Zan — serves as bait in a daring aerial maneuver to ensnare one of the attacking dragons and harpoon it. Shots of the free-falling archangels were filmed against greenscreen with the stunt performers in wirerigs designed by physical effects supervisor David Gauthier.

Based on the location and density of particles in different areas of the volume, animators found that they could increase or decrease the opacity of the fog or the smoke in the render. “In Armageddon,” Dan DeLeeuw noted, “we got wispy cloud-like effects, done with lots and lots of points, which were noticeable once you got close to them. But in this film, since it was volumetric rendering through voxel theory, we didn’t have that problem. The subtle interactions with the atmosphere really made the dragon feel more like part of the scene because the CFD sold that physical correctness.”

Though CFD engines had been used before — in such films as *Shrek*, *The Perfect Storm* and *Pearl Harbor* — The Secret Lab would push the envelope on its application, finding more and more uses for it once the tool proved fairly bulletproof. “We had a lot we wanted to do with it,” said Driskill. “We knew that other companies had started down this path before us and that we were not the first to apply CFD in a broad way, but we really wanted to raise the bar. Considering we started from zero, I’m really proud of how far we got. I think we created one of the best systems around right now, and it’s full-featured. We did a lot of different kinds of work with it — everything from fog, with the dragons swooping around in it and the mist swirling off their wings, to fire breath. The beauty of the CFD engine was that it allowed us to start from a solution that was as physically correct as possible, then build a suite of tools around it to make it as art-directable as possible.”

All data traveling in and out of the simulations was processed through Houdini, which allowed for manipulation and layering of the results in the computation with other particle animation techniques. The layering proved important, with some scenes having all the different elements that could be generated by the CFD tool, to which might be added distortion from heat convection currents. To avoid bogging down routine rendering, The Secret Lab set up a network of Linux machines to run the computationally intensive simulations and associated rendering. The system was operational by the time live-action plates began arriving in May 2001.

Reign of Fire opens at a construction site where an excavation crew is working to extend the London Underground. Having gone there to see his mother, who is the construction site manager, twelve-year-old Quinn Abercromby ventures into a newly excavated cave where a predator lurks unseen. The creature — an ages-old dragon that has lain dormant for centuries — escapes its confinement and blasts everything in its path, breathing fire as it roars down an underground tunnel and up an elevator shaft to freedom. Live-action for the scene was filmed on a large cavern set built at Ardmore Studios by production designer Wolf Kroeger and his crew. Since the stage at Ardmore measured only 100 feet square and 30 feet tall — smaller than the dimensions of the dragon itself — the ceiling of the practical set was later digitally extended by The Secret Lab.

While views of the shaft and a part of its interior were filmed on location, the complete environment was also captured in quarter-scale on a 50-foot-tall elevator shaft model, built outdoors at The Secret Lab’s stage by model shop supervisor Tony Meininger and his crew. Visual effects director of photography Scott Beattie filmed the model with scale fire elements provided by Reelistic FX. Integrated into the design of the shaft was a motion control camera system that ran up the shaft at about 20 feet per second, just ahead of the fire. Meininger also

built a black tunnel — essentially a scaled-down version of one that was used on the live-action set in Ireland — to serve strictly as a form for capturing the big fireball that rolls through the tunnel.

Though Quinn survives the encounter in the cave, his mother does not. Following the incident, the story leaps ahead twenty years to a walled castle keep in Norwich — in reality an enormous façade built by Kroeger on the foundations of a real castle ruin near Bray — where the now-grown Quinn (Christian Bale) and a ragged band of starved and dispirited survivors are holed up. The first clear view of the dragons occurs when one swoops down to carpet-bomb a field in which some of Quinn’s people are hastily harvesting crops. It lands in front of a rescue fire truck and flames it, eventually settling on the ground to devour the ash remains. The field attack would also offer up the movie’s first clear reveal of the dragons’ fire weapon in action.

Practical flame effects for the CG dragon had been rigged on location by special effects supervisor David Gauthier, who produced them via an enormous liquid propane flamethrower. “It was based on two three- or four-inch fire hose nozzles that were spaced exactly the width of the dragon’s head and mounted on a huge tractor,” Richard Hoover recalled. “Dave forced the propane out at some phenomenal pressure and ignited it. The flame would shoot over 100 feet, and it was so hot that no one could stand closer than 100 or 150 feet. On one occasion it burned the insulation off the electrical cable buried a foot deep in the mud. I think Rob was always afraid we were going to hurt somebody.”

“The rig was amazing,” added Dan DeLeeuw, “but since it was attached to the tractor it could only move so fast, and our dragons were often flying at 200 miles per hour through the sky. We thought, ‘Well, we could shoot fire elements against black and track them in.’ Fire is very forgiving in perspective; you can distort it a bit before it gives away the gag. But we had the dragon soaring around in the air and breathing fire that was slashing over the ground. So we thought about animating fire.”



Halted by a vast debris field, aconvoy led by Van Zan falls victim to the bull dragon’s fiery spew in a nightmarish after-dark ambush. For a wide shot of the vehicles awash in flames, The Secret Lab tracked its hovering CG dragon into a large-scale miniature setting rigged for widespread practical fire by Reelistic FX. Contributing to the conflagration was a motion-control flamethrower that enabled compositors to precisely align the dragon to its fiery exhalation.



Modelmakers fashioned scores of burned-out structures, vehicles and aircraft for the miniature set featured in the ambush sequence, assembling the finished construct on a California hilltop for filming against a real sky backdrop. Faced with a tight production schedule for the shot – one of several added late in post production – the effects team completed the miniature shoot in less than a week.

Digital fire, long the bane of the 3D animation world, would not only have to look convincing on its own, it also would have to match the practical flames created on location. Seeking an approach that was both expedient and reliable, The Secret Lab turned to its computational fluid dynamics engine. “Our animators would animate the two cones at the sides of the dragon’s mouth to aim the fire,” explained DeLeeuw, “then they would give it to our effects people, and they would do the calculation for our CFD engine. With CFD, we were able to get a lot of realistic movement that you wouldn’t be able to get with just a normal dynamics model.”

Analysis of the practical fire shot on set provided reference for the digital team. “We looked at how that fire evolved, from when it first ignites and burns really hot to when it cools off,” said DeLeeuw, “and put that same thing into our fire renderer. So our fire actually transitions through stages, from very, very hot to starting to cool off, getting more detail in it until it eventually turns to smoke. Then we switch over from the fire shader to the smoke shader. We built all of that intelligence into the shader, trying to make it look real.” Other tricks were employed to make the fire convincing, but the CFD engine simplified the task. “Previous to this, when we’d shoot fire elements on stage, people would not understand how much trickery was involved. We’d shoot fire over black, and we’d put in little blockers or scoops to get the fire to go where we wanted. The CFD engine worked enough like real life that we ended up doing those same kinds of tricks.”

Soon after the field attack, a group of Americans appears, led by the swaggering Denton Van Zan (Matthew McConaughey). With reluctance, Quinn permits the group — equipped with high-tech weaponry, armored transport and a helicopter — to bivouac in the castle. When a dragon attacks the next morning, the newcomers demonstrate their dragon-slaying skills by bringing down the beast. Their practiced method is to force the dragon to the ground so it can be harpooned — a process that involves a trio of parachutists, called archangels, jumping from the helicopter. While one of the jumpers serves as flying bait, the others maneuver into position and fire bolo nets with razor hooks in an attempt to entangle the creature.

“Initially the scene was to have been done primarily live,” noted Richard Hoover. “Production had stunt guys diving from a helicopter, and an aerial photographer. They tried that for almost three weeks, but ran into a lot of obstacles. For one thing, hoof-and-mouth disease had erupted, and the Irish government restricted the film crew’s access to the countryside; so the jumpers were limited in where they could land. Also, these guys were falling fast — reaching speeds of 180 knots — and if they’d collided with the cameraman, who was falling through the air on his back shooting up at them, it could have killed someone. It was just too dangerous.”

The solution was to simulate the free-fall on wires, and shoot it against greenscreen, allowing for camera proximity and more dynamic action. “We had something like 70 greenscreen elements to shoot in only a week,” said Hoover. “To execute that with normal wire harnesses didn’t seem possible. And, though these were beefy guys, a twelve-hour day on wires would kill anybody. So Dave Gauthier built a rig with a universal joint in the parachute backpack that attached to sculpted chest and back plates. The rig was attached to a forklift with a long boom arm that was rotatable so we could turn and pitch them to just about any degree. We put two 200-mile-per-hour fans under them and built an 80-by-80-foot greenscreen to fly them against — a hard cyc, because the wind would make greenscreen fabric flutter. We had the camera on a crane and hot-head so we got as much free-floating, free-camera feeling as we could.”

Although The Secret Lab initially resisted adding digital archangels to the sequence, especially since this work came late in postproduction, the demands of the action finally compelled them to do so for a few key shots. The violent flapping of archangels’ clothing entailed the writing of some new code to simulate the fabric dynamics.

Most of the archangel sequence had the men free-falling through layers of clouds. Live-action plates of clouds filmed from the helicopter proved unsatisfactory, as they did not have the thick, moody ‘realm of the dragons’ feel that Bowman wanted. The helicopter also flew too slowly and did not actually enter the clouds. Plates from a skydiver camera were equally disappointing because the clouds were never thick enough and appeared on screen as if the viewer was passing through them horizontally rather than vertically. CGI, again, seemed the only feasible means of providing the clouds required for the high-energy, midair cat-and-mouse game.

“With greenscreen skydivers against a cloud background, it had all the potential for looking like the worst thing in the world,” admitted John Murrah, “but we took photographs or painted clouds and extruded them into a volume via Jig. That allowed us to actually fly through a cloud without it ‘popping,’ as it would going through a discrete card. With this cheat we were able to sculpt clouds and change them depending on lighting conditions. Using fractal noise, we created pockets of higher and lower density inside so that it wasn’t obviously an extrusion. Then we used the same rendering tools that we’d built for the CFD fog and smoke. Also, the rendering times were about a hundredth of what volumetric particle clouds would have been. To ensure the correct perspective, Rob came up with a series of rules, like tilting the ‘camera’ so that the vanishing point would be in the upper center of the screen for falling away, in the lower center of the screen for diving, or in the lower left if chasing something down into the clouds.”

Inevitably, the green of Ireland was often captured in the plates — an inappropriate contrast to the ravaged, ash-covered earth of 2022 depicted in the story. The archangels' descent especially suffered from this problem because of the low angle of the camera in the live-action plates. For a shot of one jumper, unable to deploy his parachute, bursting out the base of clouds just moments before impact, The Secret Lab provided a miniature landscape, extended with a matte painting. In other instances, Cinesite London performed green removal chores, along with some odds-and-ends compositing and rig removal.

When the archangels fail to bring the dragon down, Quinn serves as bait to lure it into range of Van Zan's harpoon. The speared creature's crash to earth was largely achieved with the digital character, but the resultant explosion of dirt and ash had initially been intended as a practical effect. "The production had tried doing some stuff with explosives," commented John Gray, "but everything just wanted to go vertical. They couldn't really get the debris to shoot out at a 45-degree angle the way an impact would, so we built a cable system that propelled a 'plow' down a wire and slammed it into some light-colored debris. We went at it as hard and fast as we could, playing with different angles and different shapes of plows. We shot that against a black background, and then The Secret Lab colorized it." In the end, The Secret Lab produced most of the debris digitally using its CFD engine to simulate the interaction of the debris elements with the CG dragon and the ground.

Since the dragons were usually airborne, and direct contact with humans was limited mostly to shots of the creatures snatching burned bodies from the ground, there was little need for a full-scale, articulated dragon to interact with performers on the sets. One exception, however, was a scene in which Quinn extracts an egg from the female dragon felled by Van Zan. The task of creating both the egg and downed dragon was awarded to Artem, an effects house in West London. The Secret Lab provided Artem with a maquette of the dead dragon in the desired pose — produced by Miles Teves and his team — along with files of the dragon coloring and other data. Mike Meaker, who designed the egg, sent conceptual art for that.

By the time the artwork arrived at Artem, the company had only ten weeks in which to deliver the dragon prop — the biggest project in its history. "The body was about 33 feet long without the tail, which was going to be put on in CG," said Chris Martin, who supervised the work. "We built one wing about 120 feet long, and the other was



The bull dragon backtracks VanZan's expedition and unleashes its deadly fire on the castle fortress where Quinn Abercromby and the remaining survivors are holed up. Elaborate practical flame effects rigged on the live-action sets were supplemented with digital fire driven by simulations based upon computational fluid dynamics. The CFD system was also invaluable in creating interactive fog, smoke and ash — the ever-present fallout of dragon attacks.



CG. We scanned the maquette and generated cut-through slice data so that we could make accurate polystyrene forms. Then we took back an inch of area that was going to be rubber, and put clay all over the forms to get a better final surface for molding. We made a multipiece fiberglass mold and used two-part rubber backed up with strong fabric because it was such a heavy thing. We used emulsion-type paints, some mixed with latex depending on where we were applying them. The wing was semi-translucent in places; so for almost all of that we used wood stain. The teeth were made out of acrylic so you could see through them and have a kind of x-factor.”

In a bold and desperate move, Van Zan and Quinn journey to London – intent upon killing the bull dragon in its underground lair – arriving just as dozens of lesser dragons take flight over the ruined heart of the city. Wide establishing views of the incinerated cityscape blended live-action with miniature sets, matte-painted extensions, and digital clouds, smoke and dragons. Thorough previz and extensive survey data gathered from the live-action shoot aided the digital team in achieving a seamless blend.

Since the dragon was supposed to be alive — though just barely — modelmakers had slime oozing from the mouth, and glands inside it that moved as the beast breathed. “We had a big pneumatic mechanism in the body for the breathing,” observed Martin. “For the scene where Christian cuts through and removes the egg, we used the rig like a defibrillator, so the dragon reacted with kind of a wobble. The eggs themselves were made of clear polyurethane with a dragon embryo inside.”

The massive dragon prop was designed to fold up so that it would fit on two 40-foot trailers. It was then transported to Ireland and assembled by an eight-man crew. “After we got it up,” Martin recalled, “the director took a stroll around it. It was a tense moment, because he hadn’t seen it since it was half-made, but he said, ‘You’ve hit a home run,’ and that was very encouraging. It was shot over a couple of days in smoky, wettish conditions. We dribbled artificial blood on the dragon, so it was like an abattoir inside it — and we had seats in there where our crew controlled the pneumatics. They had to pass the egg into Christian’s hands because it was covered in slime and he couldn’t get a grip on it.” For later shots featuring the carcass of a mauled dragon, the Artem crew ripped the prop apart and put it back together to make it look like a different beast. “We took the head off and threw it across the warehouse and made a lot of entrails to dribble across the floor.”

After Quinn and Van Zan lock horns over how to defeat the dragons, Van Zan organizes a military convoy that sets out for London to find and destroy the bull dragon, whom the American believes is the only remaining male and key to the species' survival. The 'Road to London' sequence was one that the filmmakers would end up enhancing late in production, when more than a dozen new effects shots were added to the picture. "Because of the budget, we had tried to prune down the effects as far as we could," explained Rob Bowman, "but it ended up being more than I felt was good for the movie. After seeing the film cut together, the producers agreed. Most of the added shots were sporadic throughout the movie — one here, another there, adding frames to an existing shot — wherever we felt like we were missing a beat. The 'Road to London' sequence was a more mammoth venture; but it was one that I felt we needed, because it was a major turning point in the story."

In the nighttime scene, the convoy comes upon a massive debris field of destroyed vehicles and aircraft blocking their way — the wreckage of previous attacks by dragons on former ill-fated expeditions. Van Zan's party quickly meets the same fate when the bull dragon ambushes them, descending out of a smokescreen he has created and decimating the column of vehicles in a wash of fire. The shot was executed by The Secret Lab on an enormous sixth-scale miniature of the destroyed landscape and convoy, built by Tony Meininger and his crew, and assembled atop Mystery Mesa, in Santa Clarita, California, so that only open sky would appear in the background.

The miniature shoot benefited from detailed animatics based on survey and camera data from the live-action portion of the sequence. Reelistic FX again provided the all-important fire effects. "They wanted to see dragon's breath shooting from the CG dragon up in the air and hitting the ground, and the ground erupting in fire with this huge cloud of smoke rolling in," explained John Gray. "So at first, we were just going to provide an interactive fire that wrapped around the vehicles and went under them — the really hard stuff to create in CG. But then I thought we could actually build a flamethrower and make it motion controlled so they could tie the CG dragon into our moves." To accomplish the trick, the Reelistic Effects team dug a trench the length of the 200-foot-long set, and built a steel-and-wood tunnel equipped with a subterranean track and a motion control flamethrower. "We could pan and tilt and have all the different moves we needed; and with the motion control winch, we were able to program it so that it did the same thing each time. It would come screaming down the track at about 15 feet per second, and blow out, through a nozzle, this liquid fire mix that we created, shooting flame across all the vehicles." For the rolling cloud of smoke, Gray and his crew also surrounded the set with smoke machines, though their practical cloud ended up being replaced by digital smoke and embers created by The Secret Lab.



Modelmakers at The Secret Lab built expansive and detailed miniatures of destroyed London in two different scales for the film's climactic confrontation between man and beast. In addition to Parliament, replicas were built of such recognizable landmarks as Big Ben and Westminster Bridge, with views of the city extending to the Thames River.

The bull dragon backtracks Van Zan's expedition and launches a devastating attack on Quinn and the others who remained behind at the Norwich settlement. To depict the fiery destruction of the castle keep, The Secret Lab created a matte painting — based on its 3D model of the set — to replace the top portion of the real set with images of the collapsed and burning structure. Animators also used the CFD engine to create smoke, flying embers and the dragon's fiery breath. Digital Dimensions, brought on late in the production, contributed another painting to represent the smoldering castle ruins the following morning.



Severely burned by a pyro-laden crossbow shaft, the bull dragon is forced to the ground where it stalks its human adversaries, spewing dual streams of highly combustible chemicals that ignite upon contact with each other. For shots of the injured beast in the air and on the ground, digital artists painted new texture maps to simulate the look of scorched scales and exposed muscle and tissue. Digital smoke emanating from the burn wounds enhanced the illusion.

When the ragged survivors of Van Zan's ill-fated expedition return to the castle, Quinn decides to join the American and his helicopter pilot, Alex Jensen (Izabella Scorupco) in a desperate plan to kill the progenitor dragon. They fly to London and land in a dry-dock – in reality an actual dock in the Dublin harbor that had been drained of water — then set out for the bull's lair, the very site where Quinn first confronted the beast twenty years earlier. The climactic sequence called for establishing shots of London's destroyed city center seen by the characters as they climb up the edge of the dry-dock, and broader views for a later scene in which Van Zan climbs a 300-foot-tall brick chimney for his final face-off with the dragon. Shots combined live-action, miniature landscapes to extend the foreground elements, CG matte paintings to extend the miniatures, and animation elements such as clouds, smoke and dragons. The photography from the chimney POV was driven by scaled motion control data that was obtained from a live-action shoot in Dublin.

"The dry-dock miniature was very specific," stated Tony Meininger, whose crew built both London scenes, "to the extent that you see a destroyed Parliament, Big Ben, and a view across Westminster Bridge — all of it dressed with debris. It was 1/48-scale, and probably 30 feet wide, with a 35-foot-deep bridge. The other model was 1/32-scale, and, at approximately 40 by 100 feet, filled most of the stage. We took survey data from the live-action shoot in Dublin, and any drawings we could get, and re-created the buildings in the sets, since the camera angles they were shooting from didn't hide the fact that the sets were incomplete. We extended those foreground buildings, allowing for the live-action to take place in between them. Then we continued to build the rest of London out to the Thames River beyond that foreground area. Both miniatures were pretty grand builds. I think the important thing was the previz and the 'handshaking' with production in terms of data and information interchange. The stuff was quite seamless in compositing."

Van Zan's climb to the top of the chimney would feature additional elements, including a Digital Dimensions CG stunt double that was inserted in place of McConaughey. From his precarious perch, Van Zan entices the bull dragon to attack, hoping to draw him close enough to fire a crossbow bolt with an explosive head. Though the wily beast dodges the projectile and blows it up with a burst of fire, one whole side of its body is severely burned by the blast. Enraged, the dragon snatches Van Zan — another digital double created by The Secret Lab — as the warrior leaps from the chimney in a final act of defiance.

To depict the injured dragon, artists at The Secret Lab had to come up with an entirely new set of surface maps for their model that would simulate the look of seared scales and exposed muscle tissue and flesh. "To get ideas, we looked at photos of burn victims from medical journals and all kinds of gross stuff," said Hoover. "Then one day, I said: 'You know, I come from Washington state where we used to buy half a cow for the family. Let's just go buy one of those and burn it — and we'll film it.' I wanted a cow with skin on it so we could see what the skin would look like burnt; but U.S. Department of Agriculture won't let you buy a cow with skin on it — it's not healthy. So we went to a grocery store and bought some beef, sliced it thin and put it on glass; and I had John Gray burn it in all different kinds of ways. First we put Crisco oil on the glass; then we put the meat on that, and cooked it. All the edges of the meat started curling and getting black and crispy, and the oil started going red and bloody. It was beautiful!" The effect was photographed and those photos were used for texture maps painted by Mark Siegel. The paintings were augmented with digital smoke emitted from smoldering burn holes and animated with the CFD engine to waft realistically as the CG dragon flew through the air.

The dragon's injuries bring it to the ground. There, Quinn faces his nemesis in a scene that reprises his first meeting with the beast as a young boy, when he narrowly escaped immolation. With one of the flame-producing glands hemorrhaging from the dragon's damaged face, the creature is unable to use its primary weapon. Quinn fires his crossbow, which penetrates the dragon's neck, erupting both glands so that a gush of the volatile chemical hits the ground, already saturated with a pool of the fluid. The result is a napalm-like explosion that rips open the beast's chest and neck, killing it.

In the end, *Reign of Fire's* total number of effects shots numbered just 118 – a modest figure by today's standard of effects-driven shows. But, given the size of each of those effects shots, the number did not accurately reflect the scope and challenges of the project. "This was by far the most complicated picture I've ever done," Richard Hoover affirmed. "The tiers to every shot were just so vast that anytime we changed anything, beginning with animation, it would domino and we'd have to go back and start over again. The layers to the dragon itself were enormously complex, and everything affected by that – the lighting, the smoke that interacted with the dragon, things it was hitting or what was going on behind it – couldn't be done until the dragon was finalized. When we tiered through all those other layers it became enormously time-consuming, and it took months for every shot."

Reflecting on the arduous process, Rob Bowman was more than satisfied with the end result. "Before I signed on," Bowman acknowledged, "I said this movie would be worth doing only if we had the best dragon anybody's ever seen. If I didn't have believable dragons, I wouldn't have a

movie; so I had to be sure that the quality of the effects were first-class. It was a long journey, but I think we were successful in making the movie we set out to make.”

Bowman’s praise for the effects team proved bittersweet when Walt Disney Studios announced midway through postproduction that it was shuttering The Secret Lab, following completion of Reign of Fire and one other project slated for release. The closing would bring to an end more than two decades of outstanding and award-winning effects by the company, initially founded in 1979 as Dream Quest Images, then renamed in 1999 after being absorbed by Disney.

Despite the disheartening news, artists at The Secret Lab was happy to be going out on a high note. “When I came into this movie,” reflected Richard Hoover, “I looked at what we had to do, and I knew it was going to be pushing everything we had. The tools all had to go up another notch. But after doing this for so many years, I believe that if you feel a picture is going to be really difficult, then you have a better chance of doing something really special. And in this movie, I think we succeeded far beyond what I’d imagined.”

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Future Reality

image

ARTICLE BY JOE FORDHAM

Twenty years ago, film director Ridley Scott brought Philip K. Dick's novel *Do Androids Dream of Electric Sheep?* to the screen as *Blade Runner*, and the darkly moral cybernetic thriller changed the way Hollywood felt about the future.

A spate of moody science fiction movies — some adapted from Dick stories, others simply inspired by *Blade Runner* — followed Scott's landmark production. Then, in 1990, *Total Recall* blasted onto theater screens. That film, adapted from Dick's short story, "We Can Remember It for You Wholesale," was set on Mars and starred Arnold Schwarzenegger as an adrenalized version of Dick's tortured modern man lost in a maze of alternative realities. Vigorous boxoffice response to the film led screenwriters Gary Goldman and Ronald Shusett to scout potential source material for *Total Recall II*. They seized upon "The Minority Report," a Dick short story first published in 1956.

The story posited John Anderton as a middle-aged commissioner of a future Washington D.C. 'Precrime' law enforcement division, accused of a murder in a world where precognitive telepaths — 'precogs' — predict impending homicides with unerring accuracy. The premise, transposed to Mars, failed to gel as a *Total Recall* sequel; but, rewritten by Jon Cohen as *Second Sight*, and set back on earth, the material eventually attracted the attention of actor/producer Tom Cruise, who brought the screenplay to filmmaker Steven Spielberg. In January 1999, Twentieth Century Fox and DreamWorks Pictures announced the superstar actor and director were joining forces to bring Dick's story to the screen as a futuristic film noir, rewritten by Scott Frank as *Minority Report*.

Frank's screenplay begins with Precrime Captain Anderton (Cruise) and his precogs preempting a murder in a suburb of Washington D.C., 2054. When a federal inspector, Danny Witwer (Colin Farrell), arrives to breathe down Precrime's neck, Anderton proves himself a hardboiled company man, defending the system which has infallibly prevented murders for six years. The captain's resolve is tested when the precogs feed him images displaying Anderton clearly committing a homicide himself. Ignoring the advice of Precrime director Lamar Burgess (Max von Sydow), Anderton assumes he has been framed and begins searching for the man he is supposed to kill in thirty-six hours, becoming a fugitive in an Orwellian world where every citizen is catalogued by retina scans.

Preproduction on *Minority Report* — initiated prior to *A.I.: Artificial Intelligence* — marked Spielberg's first foray into a full-fledged futuristic world. To help develop a distinctive yet plausible backdrop for the film, he and production designer Alex McDowell consulted a 'think tank' of scientists and futurists to brainstorm potential technological advancements. Scientific dignitaries included Microsoft founder Bill Gates, novelist Douglas Coupland, virtual reality pioneer Jaron Lanier and representatives of the Massachusetts Institute of Technology Media

Lab. Topics of discussion included urban growth, computer interfaces, work and leisure lifestyles, and transportation systems.

Conceptual designer Katherine Jones, founder of the design company Milkshake Media, joined the group to define some of the wilder concepts suggested by Dick's premise. "I worked with Neil Gershenfeld, director of the physics and media group at MIT's Media Lab," noted Jones. "He was involved with figuring out the science of Philip K. Dick's story. How would it be possible for people to see two weeks into the future and how would that be imaged out of peoples' brains? One of Neil's theories was a quantum physics concept called 'Entanglement Theory.' The theory states that when you force an atom to emit two counter-propagating photons, one photon remains at the point of origin while the other travels forward in time. Because these particles are intimately entangled, if you split the photons in the precog chamber, the 'experiences' of the photon going forward in time would reverberate in the chamber and allow the precogs to 'see' into the future. I created a one-page diagram in Photoshop explaining this so everybody could understand it quickly."

Milkshake Media also illustrated radiology theories that offered ways to reverse-engineer an image from a subject's 'mind's eye.' These fed into designs for precog monitor readouts created by Jones and Brad Phillips. "When we got down to a subatomic level," said Jones, "we started to notice patterns of organic order. For instance, bacteria grow in concentric circles; they're very chaotic, yet they're very ordered. We took that theme and applied it to our screen graphics."

To explore the broader sweep of the future world, McDowell contracted Pixel Liberation Front to develop 3D animatics even earlier in preproduction, in 1998. "Alex's approach was fascinating," said PLF previsualization supervisor Ron Frankel. "He was not simply looking for us to produce traditional animatic shot and sequence design, which we did eventually; he wanted to use us as a conceptual design tool. Alex and Steven wanted to create a future that was remarkable and had a 'wow' factor; but it had to be believable. The tag line they came up with for the film was not 'science fiction,' but 'future reality.' Every aspect of this world — the architecture, the transportation, the props — had to appear to have evolved so the audience would understand how we got from here, today, to there. They didn't want a huge disconnect."

Frankel, Colin Green and their animation team spent three months building and animating 3D city models in Softimage, producing key-frame animations to illustrate futuristic Washington D.C. and its transportation system, laying foundations for art department conceptual artists. "In our 3D modeling," said Frankel, "we came up with massive models in broad strokes, very quickly describing the structure of the city, working out who lived where and how people got about. Our primary focus was the big panoramic-type shots, which were all going to be visual effects. Alex utilized us to design elements that would typically get handled in postproduction; so while set designers worked on the physical sets, we could work on everything that would wrap around those as matte paintings and CG set extensions."

Industrial Light & Magic also consulted on the project in its early stages, along with Pacific Data Images — now PDI/DreamWorks — until two press releases appeared on March 14, 2000: Fox confirming a one-year hiatus for *Minority Report*, Warner Brothers announcing the start of A.I. In early 2001, *Minority Report* resumed, assimilating many members of the A.I. production team. ILM's Scott Farrar stepped up as senior visual effects supervisor. Michael Lantieri returned as physical effects supervisor. DreamWorks visual effects producer Mark Russell also recruited the PDI/DreamWorks A.I. team of Henry LaBounta and Les Hunter, while PLF and a number of new studios in the Los Angeles visual effects community supplemented the creation of a very different futuristic film.



A nearly fifty-year-old short story by science fiction writer Philip K. Dick formed the basis for *Minority Report*, a futuristic thriller directed by Steven Spielberg and starring Tom Cruise. Both story and film center on the character of John Anderton, captain of a future 'Precrime' law enforcement division in Washington D.C. Relying on the visions of precognitive telepaths - 'precogs' - the unit apprehends homicidal perpetrators before they commit their crimes.

A montage of soupy, abstract images emerges from the initial fade-up as John Anderton downloads transmissions from three precogs — Agatha, Arthur and Dashiell, named after the noted detective novelists Christie, Doyle and Hammett. Conceptual design studio Imaginary Forces — designers of the award-winning main titles for *Seven* — created imagery for the precog downloads, known as 'previsions' in Precrime parlance. "Our first round of conversation with Alex McDowell was to discuss general concepts about media in the future," said Peter Frankfurt, co-founder of Imaginary Forces. "When the movie was put on hiatus and started up again, Alex asked us to think about the nature of the previsions, how they would appear to Tom Cruise's character and how he would break them down into clues to stop the crimes before they happened."

Frankfurt's partners, Kurt Mattila and Matthew Checkowski, led designs from Spielberg's open brief, which called for a visual style that stood apart from the main narrative. "Steven was very clear," recalled Mattila. "He didn't want the previsions to feel like a movie. They had to feel as if they were live feeds from the precogs' minds. This was very different from the short story, which just gave Anderton a punch card with the perpetrator's name. Steven wanted to show a visual representation of a dream." Mattila and Checkowski consulted with a cognitive psychologist to review clinical definitions of dream imagery and the nature of memory. "We found that the first thing the brain does when a person is witnessing a violent crime is to go into a mode of self-preservation. This affects that person's input in terms of what he sees and hears; and elements go missing from the scene when he tries to recall it. Most people's memories work that way. If you leave a room and try to recall, say, the color of a pillow on a chair, you might be a little fuzzy on that specific detail. Memory is not always linear."

Applying the theory to the first prevision in the film — suburbanite husband Howard Marks stabbing his unfaithful wife and her lover in a flash of jealous rage — Imaginary Forces created

the fragmentation of imagery by fusing various takes with selectively removed props. “We decided the three precogs had different points of view of this murder,” explained Checkowski, “so each precog would not remember the same details. As we shot each take, we removed an element of the scene: a table lamp, then curtains, then characters. Then we edited between those takes, producing an organic collage where details of the scene would flicker in and out of existence.”

The visual language for the previsions also included distorting objects that the precogs could not quite recall, some parts coming through faster than others, like a photograph developing. “We desaturated events that were further away in time,” observed Mattila, “making them more black-and-white, while recent events became clearer and more colored. Then we layered different takes together, so the previsions were constantly breathing and alive, not just a video feed.”

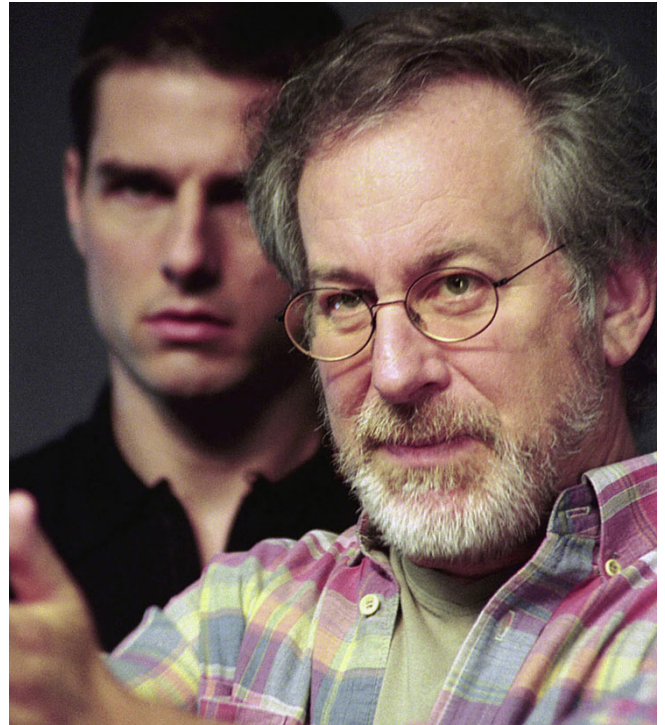
Janusz Kaminski photographed the Marks murder at 120 frames per second and utilized a Kawasaki robot arm designed for assembling car parts, rented for the film by Michael Lantieri for an entirely different purpose. “Janusz and his crew strapped an Arriflex camera to the robot arm and used it to film the Marks murder,” said Mattila. “It could move from one angle to the next in half a second, and it gave us some very interesting swooping moves that we could never have accomplished in postproduction. When Tom Cruise was interacting with the previsions on the analytical displays at Precrime, he moved his arms in time with the camera moves, appearing to control the images zooming in and out.”

As the camera pulls back, the images of Marks’ prevision are revealed to be contained within the pupil of Agatha (Samantha Morton), one of three ghostly-pale precogs with glowing wires attached to their shaved scalps. The precog designs grew from Philip K. Dick descriptions and Katherine Jones’ medical research. Jones produced renderings illustrating precog development as birth defects influencing the occipital lobe, causing excess cranial development during the subjects’ embryonic growth. ILM art director Alex Laurant and a team of artists expanded on this idea, depicting the characters with withered, almost thalidomide-wracked bodies; but realizing these bizarre precog concepts would have necessitated extensive use of puppetry or computer graphics — neither of which Spielberg was anxious to employ. “Steven just wanted to rely on a good actor,” related Scott Farrar, “as he had in A.I. with Haley Joel Osment as the robot boy. Samantha Morton gave such a great performance, it was a lot better than having Tom interacting with a rig.”

The precogs float on their backs in a petal-like array of containment tanks filled with ‘photon milk.’ Michael Lantieri’s physical effects foreman, Tom Pahk, built the tanks out of white pigmented fiberglass filled with colored water. For the opening pullback, Kaminski photographed Morton standing upright with a Panavision Primo macro zoom lens focused on her pupil as the camera dollied back. He then repeated the move with Morton in the precog tank and shot the angle twice, using successively wider-angle lenses, to maintain focus as the camera rose above the set. ILM composited prevision imagery and reflections into Morton’s pupil, then digitally blended the three pullbacks into one seamless move.

The precogs’ prevision of Marks’ double murder triggers an alarm that sets machinery in motion at Precrime headquarters. A laser-cutting lathe shaves a small cube of wood into a sphere, encases it in clear plastic, then embosses the victims’ and perpetrator’s names. Color-coded balls then roll into a gumball-machine-style track — red indicating a crime of passion, brown indicating a premeditated crime. Property master Jerry Moss collaborated with Lantieri’s team in the construction of the elaborate ‘egg machine.’

PDI provided digital enhancement, adding laser beams and particulate matter and eventually animating the entire wood-turning scene. “Michael Lantieri created a pneumatic device that was state of the art,” said PDI supervisor Henry LaBounta, “with arms that moved fairly quickly. But while we were reviewing the shot with Steven and discussing animation of the CG wood block, we suggested replacing the machine’s arms to make them move faster and describe more carving movements. Steven agreed. When we scanned the plates, we started adding to our CG fixes, erasing seams on parts of the machine and little blemishes in the paint, until we realized that since there were no actors in the shot we might as well recreate the whole thing digitally. We’d already built



Cruise brought the project to the attention of Spielberg, and the two collaborated on its production under the aegis of DreamWorks Pictures and Twentieth Century Fox. Preproduction on *Minority Report* commenced before *A.I.: Artificial Intelligence*, making it Spielberg’s first true foray into a futuristic world. Contributions by Industrial Light & Magic, under visual effects supervisor Scott Farrar, and a host of other effects vendors were key to bringing that futuristic world to the screen.



To lend authenticity and logic to the film, Spielberg enlisted a team of top scientists to brainstorm potential real-life technological advancements. Among the ideas considered were the genetically engineered precogs, whose dysfunctional brains enable them to see into the future. Scenes inside the precog chamber were shot on a full-size set conceived by production designer Alex McDowell and fitted with a containment tank constructed by physical effects

a CG model to help us integrate our dust-cloud particle animation, so we took it further and just used the original plate as reference.”

supervisor Michael Lantieri and his team. Floating in the tank and attached to electrodes, the three precogs transmit their previsions to Precrime monitors.

Krzysztof Rostek animated the egg machine using a Boolean equation to realistically shear matter from the wood block in direct proportion to its size. Dust particles then showered the CG machine inside its Plexiglas vacuum cylinder, rendered with motion blur and displacement mapping in PDI’s new renderer, which made its motion picture debut on the project. Richard Chuang animated names embossing into the fibers of the wood, using as much of the photographic sphere textures as possible and indenting wood grain with subtle distortions.

Anderton responds to the ‘redball’ alert by donning a pair of virtual reality operator gloves and manning his workstation in the Precrime analytical room. Dispatchers feed Anderton data, which he then assembles on a wrap-around Plexiglas computer console, manipulating translucent moving images using hand and arm gestures to sift through clues and ferret out guilty parties and intended victims.

The analytical chamber display was based on MIT Media Lab predictions that eschewed computer keyboards and drew instead on the concept of a future world united by a global graphic language and ‘gestural recognition screens.’ Science and technology advisor John Underkoffler presented his theories to Imaginary Forces and Black Box Digital using a booklet of ‘gesture-speak’ showing pictures of an operator performing semaphore signals designed to activate computer controls. Imaginary Forces then developed a pantomime of movements from Underkoffler’s bible. “Kurt and I videotaped a guy ‘conducting’ the entire scene on video,” stated Checkowski. “We wanted to visualize how all the elements could come together in the analytical scenes and provide a reference for Steven Spielberg and Tom Cruise during the shooting.”

To prepare for scenes depicting Anderton’s skills in the analytical chamber, Cruise spent weeks rehearsing with Underkoffler, familiarizing himself with the gestural language, using Imaginary Forces’ video as a guide. When cameras rolled, Cruise stood before the Plexiglas console, taking cues from Spielberg and enacting scenes without any imagery before him. Cruise wore practical points of light on the fingertips of his operator gloves to help tie his motions into graphics. “Anderton starts broad, sifting through the prevision footage,” Mattila said. “When he really started going for clues we thought it should be more fine-tuned, both in his gestures and the interface designs. We came up with the ‘safe-cracking’ gesture, where he rotates what we



Investigating an imminent murder, Anderton manipulates prevision fragments – jarring and disturbing imagery assembled by Black Box Digital

called a 'carousel' to scrub the prevision image back and forth."

To add animated imagery dancing across the panels, the production first explored shooting animation live on set. "Steven wanted transparent screens for all the computer displays," stated Scott Farrar, "and he wanted to be able to see the image from both sides, which we knew was going to be very difficult. Everybody's desire, especially in production, was to keep costs down; so, early on, we considered using rear projection to avoid the cost of shooting plates and compositing the image."

from animation and live-action elements - composited onto transparent computer screens by ILM and Asylum Effects. For a major Asylum sequence, Cruise stood before the prop monitors on set, wearing virtual reality gloves, and moved his hands and arms in time with the prevision choreography, pantomiming placement of the imagery which appeared to sweep on and off the screen and zoom in and out at his slightest gestural command.

Computer and video playback supervisor Matthew Morrissey collaborated with Black Box and Laser Magic Productions to develop live animated screens utilizing techniques similar to Disneyland's 'Haunted Mansion' ghost effects — projecting video imagery onto sheets of polarized glass. However, though promising results were achieved using varieties of reflective materials, front and rear projection and fading on and off between multiple projectors, the physical effect could not accommodate shots in which actors blocked the line of fire between projectors and the glass.

"Nobody could figure out a way to do it live," stated Farrar. "We ended up shooting backgrounds for every shot containing transparent screen displays, and ILM and Asylum Visual Effects composited them digitally. These composites were far more complicated than anybody watching the movie will ever realize." Farrar photographed live-action plates in the analytical chamber using minimal and discreet tracking markers dotted across the Plexiglas screen, allowing Spielberg complete freedom in his camera moves and framing. "When we're less restrictive, it makes for a better shot; but it also makes it tougher in postproduction. There were many times when the camera was on a crane arm moving three-dimensionally — with boom, tilt, roll, pan, tracking, traversing, starting close in, pulling back, revealing people and racking focus, forward, backward, forward, backward. I cannot underline enough how difficult that was in the world of matchmove."

Black Box Digital spent three months designing and animating Precrime screen displays to choreograph with Cruise's performance on screen. "The console had two levels," said Black Box creative supervisor W. Kent Demaine. "The foreground panels were direct feeds coming from the precogs. Anderton cuts these up, then moves them onto the back plate where he assigns codes to visuals. The concept was for Anderton to be figuring out the who-what-when-where-why about the murders. He's looking for clocks on nightstands, views out the window, anything that will help him piece together clues about the murder. We ended up with about seventy layers of animation, each moving independently in 3D space as it's moved around."

Demaine and lead designer Jorge Almeida created the interface in Side Effects' Houdini as letterbox-shaped spreads of readouts, dials and graphics, similar in theory to a present-day nonlinear editing system. To help time the animation to Cruise's performance, Demaine compressed footage of analytical chamber plates into Quicktime movies and animated to these,

picture-in-picture. The final images resulted in 9K data files that required eighteen-hour renders. Black Box broke the images into 2K tiles with animated 'handles' at either end of shots. Asylum then tweaked timings to fit the action in the final matchmove and composite.

To free Inferno artists from laborious hand tracking, Asylum producer Blondell Aidoo set up a production pipeline with matchmove lead Matt Merkovich. Merkovich built a three-dimensional re-creation of the analytical chamber in Discreet's 3ds Max and tracked geometry to plates using Autonomous Effects' Scene Genie. "We wrote our own software to convert the camera data and geometry data into Inferno," stated Merkovich. "This enabled our compositors to lock animated elements into 3D space and match the geometry that I was passing off to them. I ended up tracking 75 out of 90 shots myself, with Michael Huber."

Senior visual effects supervisor Nathan McGuinness and visual effects supervisor Marc Varisco then worked with senior Inferno artist Mitch Drain and a team of six compositors on the interplay of animation and live-action, which took a while to perfect. "The Imaginary Forces footage looked great, and the Black Box animation was beautiful," remarked Drain, "but when we put them together we had to ask ourselves, were the images propelling the story? We sometimes had to throw out our bible of how we put the shots together to make a story point. A composition might look great on frame 12, but by frame 34 the timing of Tom's movements might obscure an important clue and the shot would fall apart. It was a very deep well of issues."

Compositors preserved reflections in the glossy console surfaces by keying through animation on the curved transparent planes. Inferno artists tracked and warped animated Precrime files onto flexible clear-plastic strips that actors slotted into monitors to transport moving images from one console to another. Transparency became an important issue, as the visibility of actors' expressions through the animation added another dramatic variable.

Pinpointing the location of Howard Marks' impending double homicide, Anderton races to intervene, with only six minutes to spare. Precops

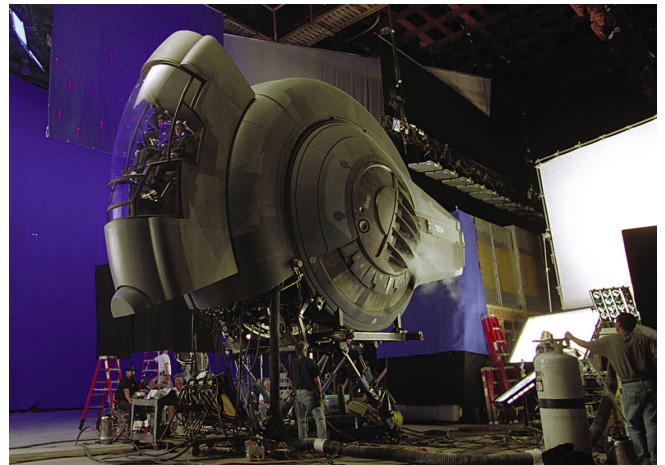
board a hovership through a narrow corridor, Danny Witwer calmly observing as they take to the air from the Precrime roof. The hovership liftoff combined a practical stage element, a digital ship exterior created by ILM and a Washington exterior. "Michael Lantieri constructed quite an extrav-agant working interior of the hovership," stated Scott Farrar. "It had two pilots at the front of the ship and all the precops in a circular chamber behind them, sitting on individual seats, four people to a row. To download the crew, a back door opened, the chamber rotated, and, as the chairs were about to go underneath the ship, the cops would unbuckle and jump off. The design went through a lot of variations with Alex's team and with PLF, then the mechanical effects crew built it to their own specifications."



Transported via a hovership, Anderton and a team of precops arrive at the scene of a soon-to-be-committed double homicide. A digital hovership modeled and animated by ILM was used for all of the flying shots, while others made use of a practical full-scale partial craft built by Michael Lantieri and his team.

Physical construction of the tall, narrow, snail-shaped flying machine — based on concept art by James Clyne — became a months-long project for the physical effects team. “Steven likes to go as far as he can with a mechanical effect,” observed Lantieri. “Wherever possible, he likes to be able to touch it, see it and shoot it. So when the hovership was on the ground with people in it, or people coming off, it was the full-size set. When it was flying, it was created digitally by ILM. One of the biggest concerns in building the hovership was size. It took us nine hours to get it out of the workshop, across the lot and into Stage 12. It then had to be moved around on a motion base and brought to a location in downtown L.A. It was gigantic.”

Working out of Lantieri’s studio on the Universal lot, effects foremen Corey Faucher and Bill Shourt led construction of the hovership cockpit, a double passenger wheel and practical landing ramp resulting in a 28-foot-tall, 14-foot-wide contraption weighing four tons. “We built the frame out of steel,” said Lantieri. “The wheels could rotate, lock into position and deploy the riders either two at a time or alternating sides. We controlled rotation using stepping motors connected to a laptop, which enabled us to position the wheels and drive them to a predetermined spot. The seats rode on posts connected to rings, like bearings inside a Ferris wheel. Everything had to be as durable, high-tech and clean as possible, so we subcontracted an aerospace company to turn the rings from aluminum on CNC mills.”



The practical hovership - which stood 28 feet tall and weighed fourtons - was bolted onto a hydraulic motion base, to allow multiaxial maneuvering, and photographed both on a bluescreen stage and on location.

Lantieri worked closely with art director Chris Gorak to detail the ship. Technicians clad the hull with fiberglass, then applied a gun-metal-gray self-skinning polyvinyl, developed for applying billboards to the sides of buses, to quickly cover compound curves and achieve a carbon-fiber composite look. Dressed with lights, flat screen video displays, bluescreen panels for the postproduction computer screen 'burn-ins' and motorized Plexiglas visors capable of descending over pilots' faces, the entire machine rode on a six-axis hydraulic motion base that facilitated wheel rotation, tilt, yaw, up-and-down and side-to-side movement.

Scott Farrar shot the hovership liftoff, working from a PLF animatic that showed the camera moving left to right from precops boarding the hovership to Witwer standing at a window backed by bluescreen. Farrar shot the window exterior, repeating the move with motion control in the rotunda of the Ronald Reagan Building in Washington D.C.



To capture location shots of precops descending from the hovership on ropes, Lantieri engineered a practical crane and cable rig, later removed digitally by ILM and replaced with the CG hovercraft.

Back at ILM, CG supervisor Barry Armour and modeler Howie Weed assembled the window view with a digital hovership exterior. "Our hovership shots weren't close enough to warrant heavy 3D detail," said Armour, "so we did as much with viewpaint as possible." Armour shot daylight photographs of the hovership rig as reference for viewpaint supervisor Elbert Yen; but the practical ship was so large and difficult to light, the textures served only as reference.

Compositing supervisor Scott Frankel, compositor Siobhan Lo, paint/roto artist Chris Bayz and technical director Todd Fulford then assembled the liftoff, placing the hovership into the live background, adding heat ripple and a retracting jetway, tracking the image into the window and animating a subtle shockwave shimmer in the window glass.

The digital hovership flies over Washington, providing a glimpse of familiar monuments and distant futuristic high-rises painted digitally by Wei Zheng and tracked into the aerial plate by Frankel's team. The hovership then flies over a Georgetown municipal park, surprising a boy on a merry-go-round as Anderton and company drop from the sky on descender ropes. Second unit stunt coordinator Gregg Smrz, effects set foreman Scott Fisher and rigging foreman Don Elliot staged the descender stunt in Washington, suspending stunt performers from a metal frame held aloft by a crane and lowering them by releasing air from pneumatic cylinders. Farrar supervised the plate photography, panning up to an empty sky. Siobhan Lo removed the crane and rig and added the dramatic reveal of the hovership in flight.

Anderton races into a brownstone in time to prevent Howard Marks from slaying his intended victims. Precops follow, wielding concussion shock guns, nausea-inducing 'sick-sticks' and a paralyzing 'halo' head-clamp — devices crafted by Jerry Moss from art department designs derived from think-tank alternatives to current nonlethal police hardware.

Having successfully averted the crime, Anderton winds down from his workday by jogging through the inner city at night, passing an enormous hologram proclaiming the virtues of Precrime law enforcement. The earnest public service announcement was one of fourteen futuristic media broadcasts created by 3 Ring Circus, a branding and design company. "Alex McDowell asked us to develop commercials for some of the world's most famous brands," stated John Sideropoulos, CEO at 3 Ring Circus. "We had American Express, Pepsi, Nokia, Reebok, Guinness and Lexus, to name a few, which all appeared as holograms. Jeff Boortz, our key creative director and designer, directed the spots, shooting for two weeks on stages in Los Angeles and in the desert near Joshua Tree. Steven placed the brands based on what made sense for the story — for instance, later, during the chase, Anderton drives a Lexus and there's a spot for Fox's television show Cops in which Anderton is the featured fugitive."

Cory Strassburger at View Studio in Hollywood and Morris Paulson at Base 2 Studios supervised the visual effects for the 3 Ring mini-productions, using Boujou, Maya and After Effects. Effects were finalized, in some cases, at 525-line video and other times at high resolution in a wide variety of aspect ratios due to the unique shapes and sizes of the advertisements. These elements were then handed over to Asylum and ILM for compositing. View Studio assembled the Precrime PSA that fills the screen after the film's opening sequence: a spinning 3D Precrime logo revealing citizens endorsing the merits of the system, then subliminal flashes of View Studio staffers appearing as apprehended criminals. ILM composited the images, with subtle corrugated textures, as giant-sized holograms mapping the sides of buildings shot in downtown Los Angeles for Anderton's nighttime jaunt.



Anderton goes for a nighttime run through the inner-city streets, passing a giant video billboard promoting the Precrime initiative, one of fourteen futuristic media broadcasts produced by 3 Ring Circus. The company's live-action and visual effects elements for the public service announcement were assembled by compositors at ILM, who added corrugated videoscan textures to the images, then mapped them to the sides of buildings shot in downtown Los Angeles.

The purpose of Anderton's run becomes clear when he meets with a stranger in an alleyway and exchanges cash for narcotics. Recognizing his client's voice, the pusher — Lycon (David Stifel) — leers at Anderton mockingly, revealing two scarred and cavernous eye-sockets. Scott Farrar created Lycon's eyeless gaze with a blend of physical and digital effects. "The makeup department did a life casting of Stifel," explained Farrar, "then they carved away the eyes. Shooting in L.A., we had Stifel say his line to Tom, then I held this flesh-colored mask up in front of camera. Mitch Dubin, the camera operator, helped me line it up correctly while Steven looked at the video playback monitor. The idea was we would pull a little raccoon matte from the mask, then plug that into the real guy's face. But when we got back to ILM and tried it, it didn't look deep or gross enough. Steven said: 'I want much more. I want to see holes going into the back of his head!'"

Farrar and Alex Laurant continued to massage the effect with Sabre artist Mark Casey, trying to create a deeper, cavernous perspective in Lycon's eye sockets as Stifel leaned into camera; but digital manipulation failed to yield an effective result. "I suggested to Alex that he should model the sockets again in real life," Farrar said. "I wanted to see stitches and gross textures. Alex went home that night and, fortunately for us, his wife Dawn was making chicken for dinner. Alex pulled the skin off of the uncooked bird, took some plastic modeling putty, modeled the eye socket interior, then sutured chicken skin into the clay and brought that in the next day." Impressed with Laurant's sewing skills, Farrar deemed the eye socket model suitably gory. Laurant photographed it with a digital still camera, then Casey tracked the textures onto Lycon. "We now call that character 'Chicken Man.' I like to tell that story because it shows that we don't only rely on digital effects at ILM. We still use every little trick we can, regardless of the source."

Back at his apartment, Anderton is seized by the munchies and begins to feed from a box of 'Pine and Oats' breakfast cereal. Annoyingly, the brightly colored box bursts to life with animated cartoon characters, and Anderton, in frustration, pitches it across the room. Farrar photographed Cruise snacking from a bluescreen box. Kurtz & Friends Animation provided the chirpy cartoon characters, which ILM then tracked and composited to the box. "We first designed the box to be Rice Krispies," recalled Bob Kurtz, "but Kellogg's pulled out because they didn't like the idea of their cereal being thrown against the wall. Instead we came up with 'Pine and Oats,' with three singing porcupines. Our goal was to make them happy and irritating so they would piss Anderton off. Shane Zalvin animated a twelve-second piece of these little guys on ones, timed to the action. We added a sticker to the box advertising E.T. refrigerator



Anderton's late-night agenda is revealed when he meets with Lycon, a shadowy drug dealer whose eyes have been extracted, either for black-market sale or to avoid the future world's ubiquitous retina scans. To create Lycon's eyeless gaze, ILM art director Alex Laurant sculpted eye sockets, then sutured real chicken skin into the clay to impart a scarred, organic look. Textures derived from digital stills of the model were tracked to actor David Stifel in the live-action plate.

magnets — ‘Collect all seventy!’ — then we handed it all to ILM. Guy Moon and I also came up with the jingle for the porcupines to sing; and we ended up with a credit at the end, right underneath the one for Schubert.”

Seated at his desktop home computer, Anderton calls up holographic home movies of his ex-wife and son — victim of an unsolved kidnapping years before — allowing him to reexperience happy moments with his lost family. Jerry Moss’ team created the desktop prop for Anderton’s computer interface. ILM and Black Box digitally generated the holographic imagery, maintaining the theme of intuitive, textless, screenless graphics. “Diskettes in the future are clear, laminated discs with little movies playing on them so users can tell what’s on the discs,” explained Kent Demaine. “When Anderton loads those into his computer, the computer scrubs back and forth, sampling words to formulate a response. One of the scientists at MIT created artwork for a display emulating words with lines in 3D space, like a Java virtual thesaurus. We generated an animated graphic in Houdini based on that visual metaphor, suggesting that as the computer pulls words out of the videos it relates them to this thesaurus, assembling recordings into playback.”

Design work for Anderton’s holographic family commenced early in preproduction at ILM, with Scott Farrar concocting a test. “We didn’t have a whole lot of direction,” recalled Farrar, “but when we showed our test to Steven he really liked it. We started with a young boy on a beach, waving and talking like it was a home movie. We filmed this looking over the shoulder of the boy’s father sitting in a chair watching this movie projected on a screen. The boy then stepped forward, off the screen, walked out into the room, and the camera dollied round revealing the boy as just a shell. He looked perfect from the father’s point of view, but as the camera went around it showed the boy was like a cutout. If he turned left or right or with his back to the viewer, he was just this front half, an embossed shape, which the camera could see through.”

Farrar developed the hologram effect in collaboration with principal engineer Steve Sullivan, motion capture supervisor Seth Rosenthal and sequence supervisor Steve Braggs, based on Sullivan’s research in image shape recognition. The effect involved surrounding a performer with an array of synchronized video cameras, then deconstructing and reconstructing the image to create a moving 3D model. Farrar shot his test subject in a greenscreen cove. Sullivan keyed away the greenscreen to create a series of moving silhouettes. By projecting silhouettes together and using the outline of each silhouette to carve away intersecting areas like a virtual ‘cookie-cutter,’ Sullivan then created an amorphous 3D mass known as a ‘golem’ — named after the mythical clay monster. After smoothing off this object and projecting it frame-by-frame with its original photographic textures, the image took on the moving dimensional appearance of the original performer capable of being manipulated in 3D space.

The photo-modeling technique enabled ILM to sidestep traditional modeling methods and compositing tricks, giving Spielberg the freedom to focus on performance without locking actors into storyboarded shots or encumbering emotional scenes with motion control. “We just used tracking markers and a washer,” stated Farrar. “We hung the washer from a three-way triangulated monofilament to prevent it from swinging. This gave Tom Cruise the eye-line with

his holographic son or wife, and helped Mitch Dubin compose his shots. As we dollied around, Tom stared at the washer, lovingly, then we painted it out and plugged in our holograms.”

Farrar, Sullivan and Rosenthal photographed Spencer Treat Clark and Kathryn Morris — playing Anderton’s son and wife — inside a 20-foot-tall green cauldron built at Twentieth Century Fox Studios in Century City. The actors stood on a platform at the center of the cylinder, surrounded by twelve digital video cameras and lights on towers swathed in green. ILM calibrated cameras using a wire-frame tower of sticks and tracking balls as a perspective reference tool; then the actors took their marks, and Farrar directed them from inside the cauldron. The decision to shoot the greenscreen elements using digital video fed into the final look of the holographic characters. “Steven wanted to see mistakes,” stated Farrar. “He wanted to see the workings of these things. We had our key camera shooting from the front, because that one had to look good, then used lower resolution cameras from the sides, which gave us interesting streaking effects and artifacts.”

Steve Braggs enhanced visual aberrations by running holograms through a JPEG compression to give surface textures a random digital look, then warped textures across the golem understructure, streaked the edges and added aura and dancing light-beam effects. Braggs created backgrounds from still photographs matted in behind the actors, Farrar supplying a shot of a location in Virginia for the beach, brought to life with animated ripples.

Visual effects editor Michael Gleason assembled Avid guide composites of single greenscreen elements that were dropped into the plate to establish blocking and anchor images into Anderton’s apartment. Scott Frankel’s compositing team and Selwyn Eddy’s matchmove team then mapped 3D geometry of the set and hand-tracked holograms into shots. “People don’t talk much about matchmoving these days,” said Farrar, “but it’s the foundation of everything we do in visual effects. An artist can match an element to the rest of the composite to a point where it can be very close, but a viewer might still see what I call ‘pixel-kissing.’ One element might move very slightly against another and it will wiggle — tick-tick-tick — and that’s damn difficult to remove. We had so much complicated 2D work on this show that it forced us to adopt new methods of tracking.”

As a crucial part of ILM’s tracking initiative, Jeff Saltzman, Brian Cantwell and Brandon Warner developed a series of plug-ins and techniques that expanded the functions of the studio’s existing tracking and matchmove program, ‘Mars,’ to create the system’s next Evolution, ‘Zepo.’ “Zepo is really a set of techniques that give artists the ability to manipulate 2D images in 3D ways,” explained Steve Sullivan. “It allows them to reposition elements in a much more natural way in 3D, rather than just by building images layer upon layer in 2D. The compositor can pull an image apart, turn it around and reassemble it in 3D, and the virtual cameras adjust and create the correct perspective.”

Throughout the hologram sequence, viewed through falling rain outside Anderton's apartment window, high-rise apartments frame the Potomac River, Lincoln Memorial and the Capitol beyond. The futuristic vista was one of five matte paintings, created by Digital Firepower, that were later transformed into 40x80-foot translites by J.C. Backings Corporation and erected on set. Alex McDowell's brief for the window imagery was to create discreetly futuristic views of the historic city. "It had to be futuristic, but not too futuristic," explained Charles Darby, owner of Digital Firepower. "Washington D.C. is probably not going to change much in fifty years. Certain landmarks are going to stay, while other structures, built from new materials, are going to grow up around them."

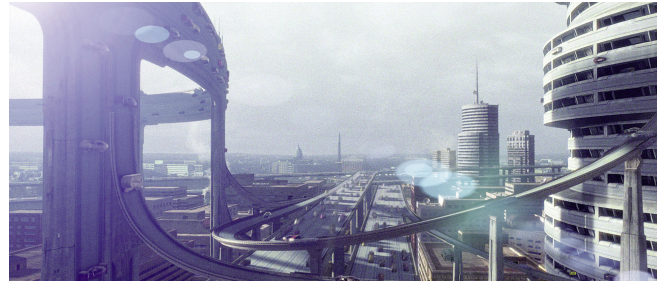
To base translites in photographic reality, Darby and still photographer Charles Lamaar shot 6x7 plates in Washington D.C., from the top of the USA Today building. Taken in the gloom of winter, the plates required considerable work to re-create the movie's summer setting, Darby placing leaves on trees, adding greenery and correcting skies. Based on conceptual art from the production art department, architectural transformations included replacing roads with park land and painting out all contemporary automobiles, phone lines and an existing bridge. Darby dropped in 2D distant structures, then added foreground buildings modeled in 3D by Jaime Baxter to ensure correct perspective alignments. Darby gleaned further real-world textures from aerial still photography of office buildings in downtown Los Angeles, which he mapped to the foreground structures. The final image was fifty percent painted and fifty percent live, at a whopping 24K resolution.

"Matte painting is somewhat of a hybrid these days," Darby observed. "In the photochemical era, when it was done on glass, it was more like mural work — it would look somewhat impressionistic close up; but when you stood back, it would pull together. Today, digitally, you're working like a miniature painter, painting with your microscope, constantly zooming in, then pulling back — and it has to look good in both senses. I don't like working in sections because it creates problems with composition, so I created each of these paintings in one piece. We had two gigs of RAM, but just to open up a file was sometimes awfully dangerous; so there were occasions when I had to bite the bullet, flatten layers in Photoshop, then continue. If I had to make a change, I would have to go back several versions to make a fix."



On an induced high from the narcotic inhaler he has bought, Anderton views holographic home movies of his long-ago-kidnapped son. ILM simulated the holographic imagery by shooting youngster Spencer Treat Clark with an array of synchronized video cameras against greenscreen. Combined digitally, the moving imagery created an amorphous 3D mass. By projecting the performer's photographic textures onto that mass frame-by-frame, the image took on the appearance of the child performer, but could be manipulated in 3D space.

Darby utilized the daytime plate outside Anderton's apartment as the basis for the nighttime view, painting glowing windows and sampling nocturnal illuminations of monuments. He also transformed views of the Mall glimpsed from Lamar Burgess' office and a view of a Georgetown brownstone seen behind Howard Marks' home. J.C. Backings expanded the images into 25-foot-long test strips, which were printed on hefty Duratrans plastic sheets. The blowups revealed pointillist detail with tiny video artifacts visible even in the curves of natural textures. The final backdrops, stretched in giant frames and frontlit, towered over sets and provided a taste of cityscapes to come.



Working from 3D animatics created by Pixel Liberation Front, ILM produced a number of all-CG establishing views of futuristic Washington D.C. and its environs. Alex McDowell's concept for the city was that it would consist of an older, historic district – featuring familiar landmarks such as the Capitol and the Washington Monument – surrounded radially by more modern, half-mile-tall suburban structures.

Anderton exits his apartment, leaping into a streamlined, bullet-shaped craft nestled incongruously in his apartment wall, which seals him in and drops out of sight. The concept for Anderton's car sprang from think-tank discussions of a computer-controlled, magnetic levitation — or 'mag-lev' — transportation system designed to supercede the fossil-fuel internal combustion engine, allowing vehicles to travel in hitherto unimagined configurations.

Harald Belker — designer of the Batman and Robin Batmobile — initiated mag-lev vehicle concepts at Trans FX, prototype vehicle specialists, which devised digital and quarter-scale articulated models. Following the preproduction hiatus, CTEK — a technology design company — built all the practical full-scale vehicles for the film in collaboration with the physical effects team. "We worked closely with Harald to mechanize the mag-lev car," noted Michael Lantieri. "CTEK supplied us with a partial chassis, with a pod that fit inside. We put precision bearings on either end so the pod remained upright as the ends rotated. Anderton's apartment was built as a two-story set, so we set a track in the soundstage floor and curved it up to the side of the apartment. We mounted the car on the rails, at the nose and the tail, with the pod gimbaled inside, raised it on a cable traveler and drove it back and forth with computer-controlled stepping motors. When Tom climbed into the pod, we lowered the car, the pod turned and he remained seated upright in the middle."

The reason for the peculiar configuration of Anderton's car becomes apparent as the camera pulls back from the exterior of the apartment. Clinging to the side of the building, Anderton's vehicle slides horizontally then joins a flow of traffic, gliding down a ribbon of road that feeds into a vertical cloverleaf interchange. Following a year's design work by Alex McDowell and Pixel Liberation Front, Scott Farrar and sequence supervisor Tom Martinek realized the 336-frame reveal as an almost totally digital image.

PLF first laid out the urban plan by scanning street maps of present-day Washington D.C., then added architecture per McDowell's aesthetic criteria. "The idea was that the older part of the District of Columbia would be maintained as a historic district," explained Ron Frankel. "The

typical Georgetown buildings would remain as high-rent brownstones, with all their current height and building restrictions very strictly enforced. This created a quaint, historic village inside suburban nodes surrounding the city, extending up to half a mile tall. We built these megastructures as radial fins, spanning away from the District of Columbia, giving a lot of attention to sunlight. The idea was that if we built these fins attentive to the path of the sun it would at least enable us to create a vision in which natural light was possible. Steven didn't want the dark, dystopian vision of a typical science fiction film; he wanted a very green, airy environment."

After PLF presented its efforts at the think tank, the designs took another spin. "Everyone agreed there was no way authorities would allow the seat of government to become this tiny little gem encroached on by these megastructures," Frankel recalled. "In fact, what would happen is what's happening today — the city is migrating across the Potomac River into Virginia. Virginia is much more pro-growth and has relaxed building codes, so it was only natural that this massive development would spring up on the other side of the river."

The concept shifted Anderton's home address to Rosslyn, Virginia, and gave rise to the need for a radical new transport system to ferry high-rise dwellers back and forth to the city, without congestion. "Mag-lev was conceived as a system where cars can drive vertically and horizontally on elevated roadways," observed Frankel. "This became the tissue upon which even more building grew." A departure from Dick's story, mag-lev became a key plot point in the film during Anderton's flight from justice and was roughly based on existing technology. "They have an electromagnetic rail system in Japan, where trains levitate one sixteenth of an inch above the track and move along in a frictionless environment. There are also prototypes called 'pulse trains' based on the same idea, where electromagnetic rings turn on and off around a vehicle, propelling it forward. Mag-lev built on both of those ideas."

PLF developed animatics that portrayed Anderton's commute from his apartment to his Precrime office, laying out mag-lev topography and throwing in as many exciting visual concepts as they could muster. "Alex wanted the spatial relationships to be accurate," said Frankel, "so we made big maps of D.C. and Virginia, and at any given moment we could tell where Anderton would be in respect to the Mall. We then created a variety of road conditions, traveling vertically, horizontally, through a tunnel, down these beautiful spiraling intersections. Steven and Alex chose their favorite parts and incorporated those into the story."

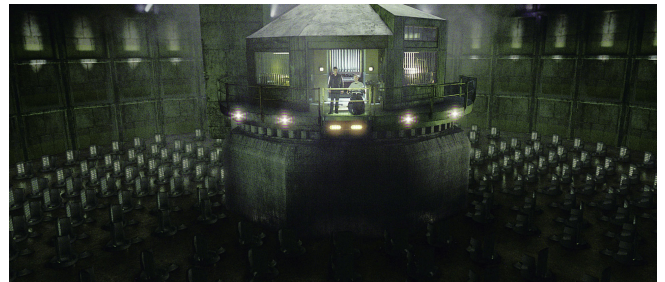
Freight elevators shunting cargo cubes and moving walkways the size of freeways were trimmed for economy; but the most radical change came after the preproduction hiatus. "Up until that point," said Frankel, "we had depicted the mag-lev cars as cubes, with roadways designed at right angles; so if a cube were to butt up alongside a wall, it could simply adhere and start traveling vertically. During the hiatus, Alex came across a book called *Animate Form* by the architect Greg Lynn, whose work incorporates a lot of curving, mutating forms. Alex was intrigued by those designs and, instead of this very angular, planned city, he decided it should be more organic. So we went back to our animatics and updated our designs with curving surfaces and diverging, converging roads."

Using 3D models of Belker's mag-lev car, Frankel and his team generated traffic flow simulations. The images enabled Scott Farrar to plot the shooting of bluescreen elements with Cruise inside his mag-lev car and laid the groundwork to address the broader sweep of the synthetic terrain. "In meeting number one," recalled Farrar, "when we first had all the department heads together, Steven held up an artist's conception of futuristic Washington D.C. with all these fancy, shiny chrome high-rises, and he asked me: 'So, Scott, why is it that in so many science fiction films the cities look so fake?' The answer was they looked fake because they looked so disconnected with what was there in the first place. It was obvious that all the new stuff had been stuck in!"

Farrar and Alex Laurant strove to realize a mag-lev transport system that would maintain a familiarity with the real world. "We decided it should be like the freeway running by ILM," explained Farrar. "There was obviously a town here before, but when the 101 came through San Rafael there was not a lot of room, so they built it up on legs. We applied that theory to mag-lev. It's obviously been added, but it's been added like a freeway. And in all cases, whenever we had buildings, we tried to prevent their looking too outlandish. We didn't want them to appear to have been made with materials that were not used today. I wanted people to see concrete, aluminum, plastic, glass; and then we aged everything to make it look integrated. That was tough with mag-lev because the concept was outlandish; but wherever we could, we tried to make it real."

The ILM art department geared up for another round of designs after production wrapped. Previsualization artist Larry Chandler created revised animatics that tailored designs to the postproduction budget. "We began extracting bluescreen elements of Tom and built our own more accurate previz models from the camera lens information," said Alex Laurant. "It was at this point that I started working with lead conceptual artist Aaron McBride, who became my right-hand man, generating illustrations and blueprints for CG construction."

McBride produced reams of sketches indicating comparative heights of megastructures and existing brownstones, alternate styles of roadway and orientation of mag-lev structures above the city. By scanning a generic aerial image of a city, McBride was able to create Photoshop composites of a hand-drawn mag-lev intersection laid over buildings, depicting height variations up to a dizzying 150 stories. "We wanted the mag-lev to look integrated," said Laurant, "not floating in the middle of nowhere. Our drawings begged all the thorny questions. How high would we need to build the surrounding buildings? Were we going to try to build mag-lev as a miniature? How



While conducting a rare tour of the precog chamber, Anderton is touched by Agatha (Samantha Morton), the most talented of the precogs, who flashes an image of a drowned woman on a monitor within the chamber. Curious, he investigates the drowning at the Department of Containment, where would-be perpetrators are stored in stasis in transparent cylinders. An ILM composite filled out live-action footage of Anderton and the facility caretaker on a central tower set, with digital set extensions providing background architecture and tombstones designating the occupants of specific pods.

much was going to be a live background plate? Could we find a location that would give us all our monuments and the Capitol in the background?"

The shot of Anderton's car leaving for work established the scale of the mag-lev system and showcased the spectacular futuristic concept. Budgetary limitations deemed miniatures too costly. Location scouts in metropolitan areas of Washington, Vancouver and Los Angeles also failed to yield suitable backgrounds, so ILM evaluated alternatives. During location scouts, Farrar photographed helicopter plates of Washington skylines. These set the palette for the mag-lev city shots and, composited into a sliver of horizon, determined color saturation and haze. ILM generated all other elements digitally.

Modeling supervisor Simon Cheung, Jack Haye and Howie Weed generated six buildings derived from Alex Laurant's designs, incorporating influences of architects Le Corbusier and Frank Gehry. "Some of Gehry's work that's being built today, like the Disney Opera House in Los Angeles, was a little too fantastic for Steven," Laurant observed. "We were striving to create a much more sober, less sexy future. Scott forced me to be very diligent about our selections of materials and stylistic embellishments, using reference of real skyscrapers to justify our designs. We didn't want anything to be gratuitous."

The design for Anderton's apartment block grew from the full-scale set whose gently curving walls and horizontally louvered windows suggested an oval, tiered design. Laurant and Barry Armour made use of repeating patterns to facilitate a modular CG modeling approach. "We designed all the high-rises with repeated shapes," said Tom Martinek. "So, instead of modeling single giant buildings, we modeled a slice of floor, made a couple of alternate versions, painted those, then wrote software scripts that allowed us to put buildings together in any form we wanted. We altered shaders on different levels, decided where we did and didn't want windows, and stacked the buildings in a bunch of different ways. It's very similar to what a traditional model shop might have done. They would have modeled one section, made a mold of that, kept repeating it, then painted that. Sometimes the old-fashioned effects techniques are still the smartest ways to do things."

Wei Zheng created 3D buildings between roadways, distant buildings and the Capitol dome as 2D and 3D digital matte-painted elements, layered through the haze. The ribbon-like mag-lev roadway and vertical cloverleaf — known as 'the hub' — occupied the foreground, populated by fleets of tiny vehicles, modeled after production art department renderings. "We made four basic car shapes," revealed Barry Armour. "We were going to make more, but we realized we could create a variety of shapes by building a few modules in sections, then switching out the ends. We relied on viewpaint to create variations of color in a more or less procedural fashion, keeping



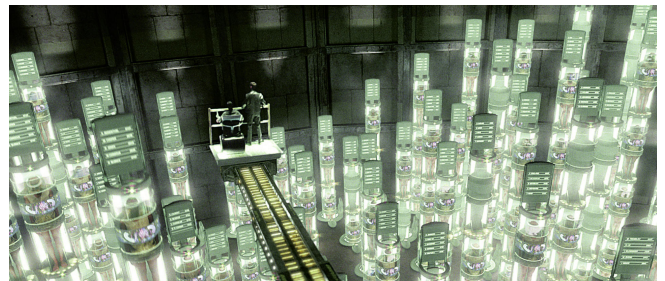
The practical containment facility set consisted of a mechanized portion of the central tower, six practical cylinders on computer-controlled pneumatic risers and a motorized, programmable boom arm furnished by the physical effects team. Live-action elements of the scene were captured

car geometry relatively simple. We had a truck, a little sports car and two types of sedan with different end caps to make one more of an inverted 'U,' viewed from the side."

with the actors atop the mechanized set, filmed against bluescreen.

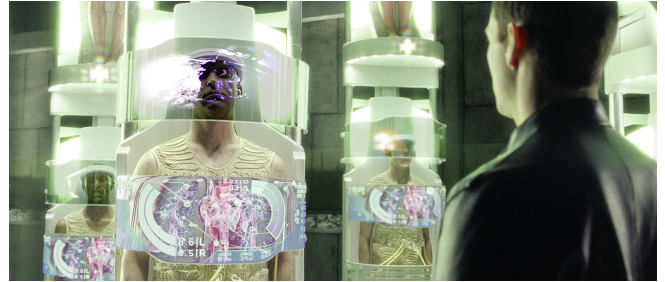
Reflections, painted weathering and a digital 'Dior filter' — a compositing process that emulated diffusion effects created by Janusz Kaminski shooting through a Christian Dior stocking — completed the look of the bleached-out, daylit mag-lev vista. "The whole look of the movie was over-exposed highlights with conspicuous grain, all put through the bleach bypass process," said Laurant. "This hammered out some colors more than others and created a bluish teal cast that almost felt like a black-and-white movie, with subtle color accents. To re-create that effect, we first produced our shots with normal brightness and color balance. Then Scott Frankel and the compositing team created synthetic lens flares, edge-wrap and overexposed skies — so all our pretty paintings of clouds were blown out almost completely. It was interesting to see all of our color design and subtle refinements nearly disappear into this almost monochromatic world."

Anderton returns to work, submitting himself to an 'eye-dentiscan' — a retina identification procedure simulated by a tiny flash of light — then hurries to rejoin Witwer on his inspection of Precrime. During the tour, the lead precog, Agatha, makes contact with Anderton's arm and reveals a flash of prevision on a precog temple monitor — a red-haired woman, underwater, frozen in a silent scream. Tracked and composited into the screen by Asylum, the prevision offered the first fragment of a sequence — designed by Imaginary Forces — containing clues that propel a mystery at the heart of the film.



Under computer control, the containment center pods rise, their occupants visible inside. To create the hundreds of 'containees,' a stage crew at ILM stood extras on a pedestal against blue, then photographed them using fifteen 35mm still cameras, arranged to capture the performers from a variety of angles. Simultaneous shutter releases produced fifteen two-dimensional cutouts that were digitally combined, using shape-recognition technology, to create each performer's rough form, onto which original photographic textures were applied.

Shaken by his contact with Agatha, Anderton investigates the identity of the drowning woman by visiting the Department of Containment, where previsions are stored along with their intended perpetrators. The facility's caretaker, Gideon (Tim Blake Nelson), locates the drowning woman on a computer screen, then leads the way to a darkened octagonal chamber where he reveals a John Doe associated with the woman's death. In a wide shot of the room, Anderton and Gideon ride a motorized arm extending from a central tower as tombstones rise from the floor beneath them, revealing a forest of vertical glowing cylinders containing bodies in stasis, stacked five persons high.



On the pod faceplates before them, containees suffer nonstop replays of their intended crimes – flickering, looped images provided by Imaginary Forces. For wide shots, ILM composited fifteen different previsions throughout the chamber, offsetting timings to disguise repetition. Black Box Digital supplied animated graphics displaying color 3D images of pumping internal organs and medical readouts, which ILM tracked and composited into the translucent panels of individual containment cylinders.

Live elements included the upper portion of the tower, six practical cylinders on computer-controlled pneumatic risers and a motorized, programmable, swinging and extending boom arm furnished by Lantieri's team, choreographed by Farrar using PLF animation. Spielberg shot the scene with Cruise and Nelson riding the mechanized set, performing against bluescreen. ILM then filled the 150-foot-wide chamber with 360 columns of bodies, digital set extensions and animation that made use of photo-modeling techniques. "To build and paint a 3D person is very expensive, time consuming and complicated," stated Farrar. "My producer, Dana Friedman, and I were pushing real hard to come up with new and easier ways of doing those shots. We decided to use Steve Sullivan's shape recognition technology with a photo gallery shoot. Makeup and wardrobe dressed nineteen 'containees.' We stood each actor on a pedestal against blue and surrounded him or her with fifteen 35mm still cameras aimed so we had left views, right views, top views, front views, low and high, radiating like spokes of a wheel around them. We triggered shutter releases simultaneously, recording our subject from all those angles. This gave us fifteen cutout shapes of each person at the same instant. We combined those shapes to create a rough shape of each actor, refined them, then applied their photographic textures to populate that area. It was a lot faster and cheaper than a traditional 3D build."

Sequence supervisor Lindy De Quattro oversaw the thirty-shot sequence, adapting Sullivan's volume modeling shader to create a photorealistic look. "The silhouettes gave us an underlying shape that looked as if it had been chipped from marble," De Quattro explained. "We processed that shape to give it a smooth surface; then I wrote a piece of code that treated each of the still cameras like a slide projector and blended textures from one projection to the next, interpolating between them. Using three values — the direction surfaces were facing, the proximity of each projector to the camera and texture brightness — I came up with a little algorithm that intelligently calculated the best blend."

Simon Cheung used traditional modeling techniques to create 3D tombstones and an upright sled bridged by three translucent restraints for each of the bodies to lay against. Elbert Yen lit and textured sleds and personalized tombstones with names of ILM staffers. Yen textured the walls and floor of the chamber as cold, dank cinderblock, streaked with grime, and modeled the base of the roundhouse as a rotating octagonal cement block with an extending arm. Roto artists matted bluescreen elements into the 3D set; then De Quattro and her team filled the room with columns, animating them to rise and fall like organ stops, clearing a path as Gideon swung the access arm around the chamber.

Black Box Digital produced animated graphics displaying translucent color 3D images of pumping internal organs and medical readouts, which ILM then tracked and composited to the central translucent panel on each of the sleds. Imaginary Forces supplied flickering previsions to play on the faceplate of each sled, subjecting comatose containees to endless loops of their crimes. De Quattro's team scattered fifteen previsions randomly through the chamber, offsetting timings to disguise repeats. Asylum composited graphics for closer views of Gideon's translucent wheelchair-mounted computer screen.

"Matchmoving was very difficult because it had to be so exact through the whole depth of the shot," DeQuattro said. "Apart from Anderton and Gideon, pretty much everything was CG — smoke, moving beams of light, glows on the floor and the general haze of the room lit up by the volumetric light. The lighting of the people on the sleds was based solely on their original still photography, so we didn't have to light them from shot to shot. This made for a very efficient render and we had most shots working by take five. We then added variety, creating different temperature bulbs on the sleds, adding lens flares, Dior effects and hot light sources that bloomed around the edges of objects. It sometimes took us until take fifty to finalize the shots."

Gideon identifies the drowning woman as Ann Lively, but is unable to shed light on the identity of her killer, a drug addict with transplanted eyes. Anderton downloads the incomplete prevision, capturing the moving image on a clear plastic 'datacard' — an Imaginary Forces image that ILM tracked, warped and composited onto the tiny prop.

The mystery of the drowning woman fails to interest Burgess, who urges Anderton to focus his attention on the public image of Precrime, now under investigation by the Attorney General. Back at Precrime headquarters, Anderton's life takes an unexpected twist when a prevision of the murder of one Leo Crow appears on the analytical chamber screen. Anderton dials into the monochromatic image and focuses on the murderer — a crewcut figure pointing an old-fashioned .45-caliber handgun — and realizes at once that he is staring at an image of himself, undeniably shooting Crow.

The Crow prevision is the only sequence that used one of four Multicam camera arrays supplied for the film by Reel EFX, creating dimensional moves through frozen moments in precog downloads. "We did some test shots with some of the latest commercial-style camera rigs," explained Kurt Mattila, "and we decided that the audience now associates those kinds of shots with the nature and language of film. The whole point of these previsions was to throw all that away. The effects looked brilliant, but they weren't quite appropriate for a visualization of

human memory. We used one Multicam rig in the Crow prevision to tie into an effect we did on our Avid, where Tom is scrolling back and forth doing his 'safecracker' routine. This gave us the natural feeling of scrubbing an image, without looking like a typical 'bulletcam' shot."

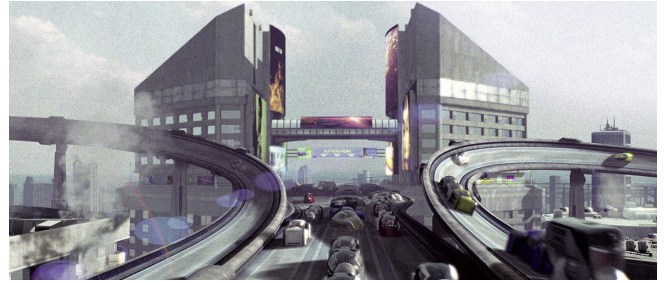
Jim Gill, president of Reel EFX, photographed the Crow murder on a bluescreen stage using eighty modified Canon still cameras aligned on a horizontal Speedrail rig. Gill triggered digital shutter releases, capturing a 180-degree arc of still frames around Anderton and Crow, photographing the killer and victim as separate passes for pyrotechnic safety. Conceived and executed at a rapid-fire guerrilla film pace, the Reel EFX rigs allowed speedy assembly and multiple takes, while four digital video cameras offered instant playback to illustrate the effectiveness of each take. Reel EFX stabilized selected takes in After Effects using custom plug-ins, then passed the 2x3K plates to Asylum artist Jason Shugardt, who assembled the final image. Shugardt built a 3D background mapped with photographic textures of an empty hotel room set. Michael Binder — the actor playing Crow — was not available for the bluescreen shoot, so a stand-in took the shot. Shugardt tracked a 2D still image of Binder's face into place and dropped characters into the 3D set with animated debris adding to the frozen gun blast.

The Crow prevision sets into action a chain of events and a final consequence from which Anderton knows he cannot escape. Convinced of his innocence, he sets his stopwatch — an Asylum graphic tracked into the wristwatch prop — and decides to run. "Tom wore a different make of watch during shooting," commented Nathan McGuinness. "The watch was a big story point in the film, seen close up to show Anderton's time to termination; but then the product placement deal changed, so we had to change it digitally. Bulgari gave us a few of their watches as reference. I designed a new bezel using the Bulgari logo, then our Inferno artist, Pink, digitally gutted the inside of the prop watch and dropped in our new design."

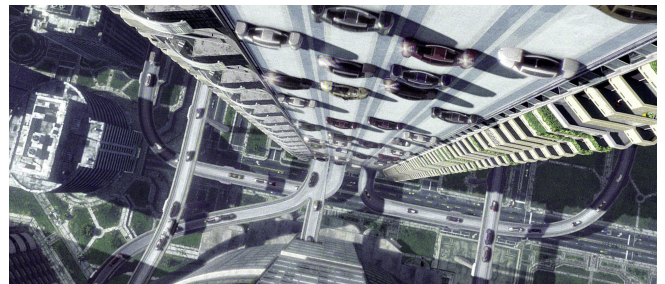
As Anderton flees Precrime in his mag-lev vehicle, Burgess appears on an internal video screen, begging him to return. Farrar filmed Cruise inside the prop car against bluescreen and later incorporated a live background, filmed from a moving vehicle on the 880/580 freeway interchange in Oakland. For corresponding views of Anderton on Burgess' holographic desktop computer, Michael Gleason culled shots of Cruise from the bluescreen shoot video tap. Frankel's compositing team then placed the translucent images inside the empty Nokia display.

Anderton is convinced Witwer has set him up; but despite his protests, Precrime takes control of his mag-lev car to bring him back to base. While designing traffic, PLF animatics pitched the mag-lev median speed at 70 miles per hour. ILM continued to experiment with speed as they finessed animation. "Time and again we were fooled by speed," stated Scott Farrar. "We animated all our shots starting from animatics, then made them look real with a lot of paint and detail. When we added all that detail, we found the mag-lev cars appeared to be traveling way too fast. We discovered that when you're doing animatics using simple shapes and colors to work out action on a small monitor, it can be very deceiving compared to when you see it fully rendered on a big screen. Once you make the animatics vehicles look more real, they appear to move many times as fast."

Anderton reacts to his predicament by booting the windshield from his mag-lev car, clambering from the vehicle and leaping across the flow of traffic. Animatics fleshed out a minimal bluescreen shoot for the scene. “When we first looked at the animatics, we all said, ‘Ohhh, man!’” recalled Tom Martinek. “When we got the bluescreen elements and saw it was just Tom jumping around on an apple box, we all wondered how we were going to do this.” Anderton’s escape broke down into 28 shots that incorporated some of the most ambitious combinations of animation and live-action in the film. At the beginning of the sequence, Anderton’s car enters a flattened tubular construction filled with 150 mag-lev cars. “We called that the ‘bobsled shot.’ Al Arthur designed the traffic flow so the cars would move in lanes, and viewpaint delineated those with patterns on the roads. Partway through, we decided to refine the viewpaint of the road surface. We had already completed the animation by that time, and the geometry was so complex we decided not to change it. In the end, we just decided it looked like we had a few traffic infractions in the shot.”



When a prevision inexplicably implicates him in a future murder, Anderton eludes capture by his colleagues and takes to the road in his magnetic levitation – or ‘mag-lev’ – vehicle. Think tank members imagined the futuristic transportation system as one employing cars that could drive either vertically or horizontally on elevated roadways. Though the technology design company CTEK built practical vehicles for live-action filming, ILM provided wide shots of the freeway and traffic via computer animation.

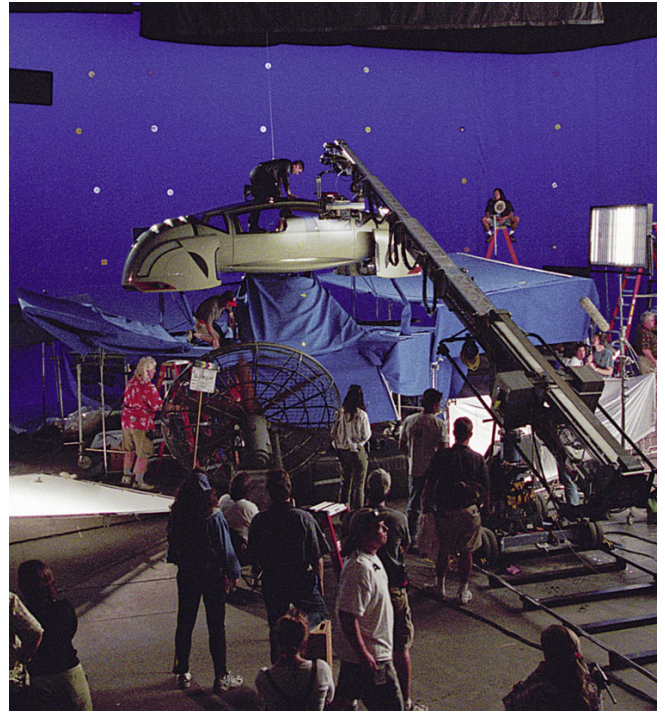


ILM also computer animated the vertiginous ‘Mag-lev Falls’ where traffic lanes flow over building tops and descend to ground-level roadways a half-mile below. To introduce visual diversity in the building balconies flashing by during the virtual camera’s plunge, ILM artists randomly applied ten different texture decals to the CG structures, then detailed them with bicycles, exercise equipment, lawn furniture and shrubs.

Viewpaint artists textured the mag-lev road, creating a subtle honeycomb pattern to indicate a metallic grid conducting magnetic energy covered by a flat protective polymer surface with painted traffic lanes. Compositors added weathering and aging as separate layers, applying grime to the roadway, modular poured-concrete supports, connecting trusses and metal railings. “The more complex and detailed that surface became, the more expensive mag-lev became to render,” noted Barry Armour. “We first tried to keep costs down by suggesting the surface should not be reflective. It turned out that it looked better reflective, so we added reflections, which meant all of the cars had to be rendered twice — once to reflect them in the road and once to reflect them in each other.”

Martinek lit background structures using ambient occlusion — 3D structures bouncing, blocking and reflecting light to procedurally create ray-traced lighting effects. Road-level detail of shiny, brightly-colored mag-lev vehicles darting in and out of shadows required a more iterative, hands-on approach. “Scott Farrar would sometimes love the color of a car in one shot,” recalled Martinek, “then he would hate it in the next, even though it was the same car and we were using the same file that had all the information locked in. Scott encouraged us to figure out what was wrong by examining real-life reference; so, after dailies, we’d walk back through the ILM parking lot and stop and stare at cars in the sunlight, in the shade, on a cloudy day, on a sunny day. We learned that color of shiny objects is very often based on the environment around them. Sometimes a dark blue or red or green car can look almost black depending on the lighting, and you can only perceive the color in the highlights and reflected areas. It all depended upon the lighting and the environment.”

To simulate that natural occurrence, Martinek and team surrounded CG mag-lev vehicles with reflection cards. “We placed four cards around every car,” Martinek explained. “We had one on each side, one on the front and a shadow card, and each card reflected in all the cars around it.



When precops take control of his vehicle and order it back to Precrime, Anderton climbs out and leaps from car to car across the flow of traffic on Mag-lev Falls. A minimal bluescreen shoot had Tom Cruise clambering atop a crane-mounted prop vehicle.



Compositors at ILM fleshed out the sequence by incorporating those bluescreen elements into a digital environment that included background structures, occupied vehicles and a roadway detailed with weathering, reflections, railings and trusses.

We had so many reflection cards in there, we ran into the hard-coded limit of the number of parameters a shader could pass in our in-house software. It was set at some ungodly high number, but we smashed into that and had to rewrite the software to finish the shots.”

Every mag-lev vehicle also needed occupants visible through transparent canopies. Farrar photographed bluescreen elements of Tom Cruise at Fox, then filled other vehicles with ILM staffers, framed from the waist up, seated against a daylight greenscreen. Distant traffic had static 2D cutouts of seated passengers tracked into place; closer vehicles had moving occupants projected onto 2D cards — compositor Whit Eldridge featured in the bobsled shot as an Aquafina truck driver.

Other details included tiny chrome Lexus emblems affixed to the body of every vehicle and dozens of holographic commercials lining the tube. One of the most prominent advertisements featured a three-dimensional holographic water snake writhing and gesticulating at passersby from an Aquafina placard. Base 2 Studios artist David Loe animated the pseudopod at 2K resolution using particle systems and water simulations, then ILM added the element to the final composite.

As Anderton struggles to escape his vehicle, traffic races towards a precipitous drop, the roadway dipping out of sight between two trapezoid rooftop structures. “We called that the waterfall penthouse,” noted Alex Laurant. “The structures on either side of the road were penthouse condo towers with a little walkway between, where people could cross to a rooftop restaurant and view the traffic going by beneath. We tried not to make our rooftop structures too Eisenhower-era looking and ended up basing shapes and textures on an existing Manhattan skyscraper.”

Anderton clambers onto the surface of his moving vehicle and clings to it as the ground falls away revealing a stomach-dropping view of ‘mag-lev falls’ — four lanes of traffic flowing over the top of the building, descending to a vanishing point far below. Farrar shot live-action for the scene with Cruise climbing out of the prop mag-lev car, rigged by the Lantieri team to tilt over a 30-foot drop on a bluescreen stage at Fox. “The only thing real in that shot was Anderton and the inside of his car,” Tom Martinek stated. “We decided we didn’t want to try to blend from the real car exterior, reflecting all the set, to our CG car. It ended up being easier to replace the car. Tom performed the stunt with the car stationary — they just rotated the car and he dangled off the edge. The live-action didn’t quite line up to the angle that we needed; so once matchmove got a lock on the shot, we used Zepo to attach a virtual camera to extend the move so it looked like the car had dropped hundreds of stories with Tom dangling from it.”



Anderton ducks into a shopping mall, where he attempts to avoid omnipresent eye-dentiscanners, which can track his position, while evading members of the Precrime unit sent to apprehend him. The sequence was filmed at a disused shopping complex in Los Angeles. Holographic advertisements were produced by 3 Ring Circus and composited into the live-action plates by Asylum Effects.

PLF animatics determined the mag-lev falls to be approximately 2500 feet tall. For animation purposes, ILM elongated the building even further, resetting mag-lev cars to their topmost start positions at the start of each shot. To avoid repeating architecture, viewpaint artists generated ten different texture decals to represent a variety of weathering patterns and randomly applied these to balconies flashing by. Martinek's team also detailed balconies with accouterments of high-rise living, adding residents, bicycles, exercise equipment, lawn furniture, shrubs and flowers.



Attempting to avoid detection, Anderton slips into an alleyway, where he is cornered by hovering precops in jetpacks. Though the ensuing air and ground action was exceptionally complex, Spielberg wanted to shoot as much of it as possible live, with real precop performers suspended on flying rigs over a controlled-environment set. Wires and rigging could then be removed by ILM, which would also provide digital sweetening for the sequence.

Descending the mag-lev falls, Anderton leaps from car to car, scaling the canopies of passing vehicles, working his way toward the outer edge of the vertical roadway. Farrar shot Cruise leaping between prop vehicles on a bluescreen set, then Martinek and his team rotoscoped the actor and placed him into a synthetic environment — adding surrounding buildings, rushing wall, careening cars, mag-lev occupants and occasionally portions of Anderton himself. “We had a closeup of Tom, seen from behind, leaping from his car,” stated Martinek. “We re-framed the shot to make it work more dynamically with our animation, dragging Anderton further into shot — but Tom was on the edge of frame, so that left us with no footage of him from his pelvis down. Pat Jarvis hand-painted and animated the back of Tom’s body, his legs and coat; and you just can’t tell where the body ended and the paint began.”

Anderton leaps onto a green mag-lev car, terrifying its occupant — ILM producer Dana Friedman — as a white car with ILM editor Michael Gleason inside, engrossed in a newspaper, hurtles by. Anderton then vaults onto a final vehicle — containing Lindy De Quattro and Pat Jarvis — and leaves his boot print on the canopy as he scrambles over. “We created Tom’s reflections by stealing a reverse angle of him from another shot and mapping that to a 2D card,” said Martinek. “We also added a digital boot print to help locate what he’s stepping on, keying through the lens flares and scratches on the glass to retain all the natural imperfections.”

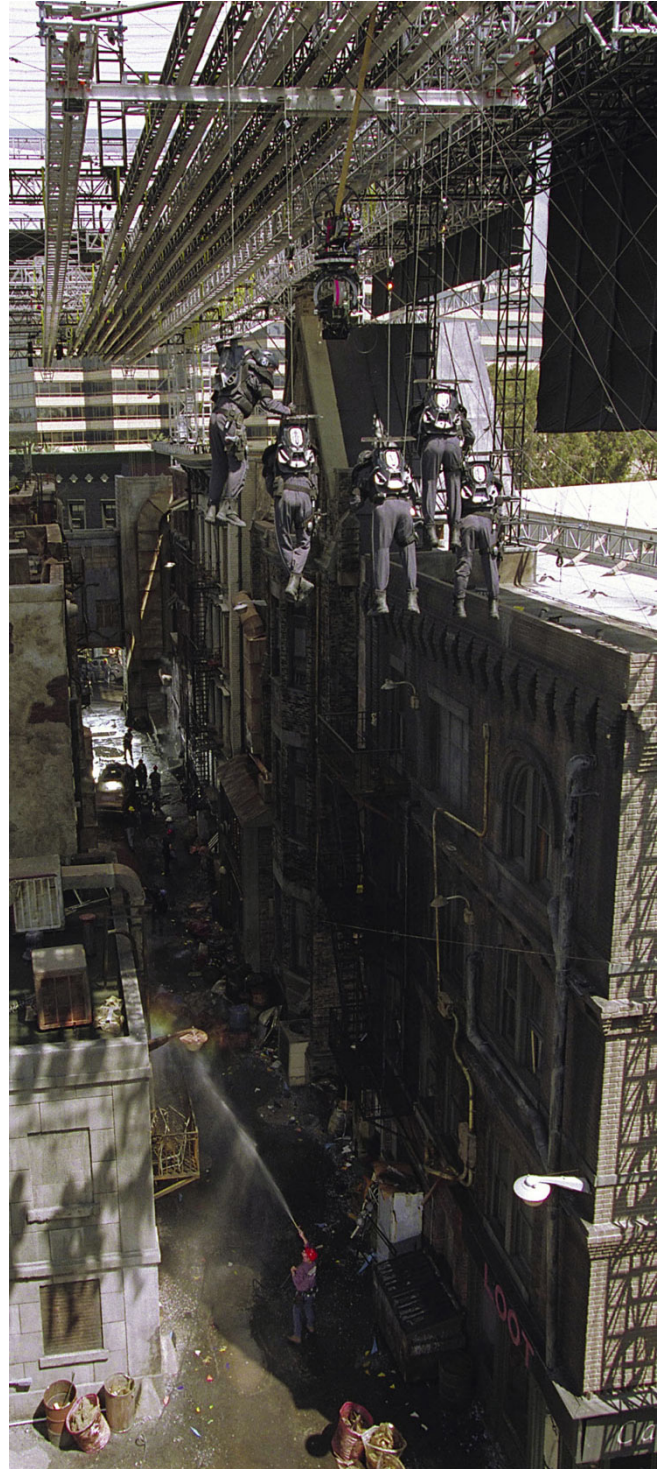
Reaching the edge-most mag-lev car, Anderton hurls himself onto a balcony, smashing through a wooden garden trellis. Stunt coordinator Brian Smrz supervised Anderton’s leap with a stunt double crashing through a trellis on a balcony set backed by blue. Composer Kimberly Lashbrook added background buildings with mag-lev traffic zipping by and massaged the stuntman’s entry into frame. “That was another Pat Jarvis paint animation trick,” noted Martinek. “The bluescreen element started with the stuntman hidden behind the vegetation; but when he came jumping in, he was not quite high enough in frame. Pat removed all the vegetation, rebuilt the guy from scratch, repositioned him, painted all that back and animated him to match as he came crashing through.” Despite the velocity of the scene, the camera

caught a glimpse of the stuntman's face at the impact with the floor, so Jarvis painted motion blur to disguise the frames, helping the shot cut seamlessly to Cruise landing.

Continuing on foot through a shopping mall, Anderton is bombarded by more holographic advertising, eye-dentiscans flashing into his retina, triggering glowing projections that spring out at him from storefronts, addressing him by name. Spielberg filmed mall scenes in Hawthorne Plaza, an abandoned shopping complex in Los Angeles, brought to life by art department and 3 Ring Circus' futuristic commercials. Asylum compositors Mark Renton and Travis Baumann layered advertising into shots, placing holograms for Bulgari, American Express, Guinness, Lexus, Nokia and One Night Stands, a fictional hotel chain. Asylum CG artist Yuichiro Yamashita also provided modeling for a 3 Ring hologram in which a glamorous woman leans out toward Anderton, opening her hands to reveal a bottle of Bulgari perfume which erupts into 3D crystals.

Anderton's retina scan immediately feeds back to Precrime, revealed as a glowing icon in a three-dimensional model of the city. Black Box generated the hologram in Houdini, working from a PLF model of future Washington D.C. and art department concepts. "Steven wanted the audience to not only see Precrime tracking Tom," said Kent Demaine, "he wanted them to realize they're tracking everybody in the city. So the shot started close on this glowing sphere representing Tom, then as the camera pulls back we see a gazillion more spheres running around the model."

Black Box effects supervisor William Robbins animated the spheres by laying splines along pathways representing roads, rooms and elevator shafts. Houdini drove sphere particles along the splines, procedurally controlling luminance values to blink spheres on and off, representing citizens passing eye-dentiscan locators. Asylum composited the hologram into background plates, paying close attention to the focal length, image



Unable to find a soundstage big enough to house flying rigs and a five-story street set, Alex McDowell built an alleyway façade on the Warner Brothers backlot. Above the towering set, riggers constructed a steel frame – 400 feet long and 50 feet high – used as a giant flying truss for Michael Lantieri's hydraulic traveling rig, capable of independently flying up to eight people at a time.

depth and transparency, and playing animation in front of actors' faces.

Anderton spots precops in the mall and ducks into an underground metro rail system. Once aboard the metro, Anderton tries to evade eye-dentiscanners, but finds himself face to face with an image of himself on a 'smart-newspaper' copy of USA Today, animated with his mug-shot and headlined "Breaking News — Precrime Hunts Its Own." "Steven wanted to suggest that newspaper imagery came to life when a reader looked at an article," said Kent Demaine. "If you look at a picture long enough, the pictures move aside and then the text rolls in, based on retina recognition." Spielberg filmed the sequence with director Cameron Crowe making a cameo appearance, holding a blank paper with tracking markers. Black Box created text and graphics, animating images of Cruise, a weather report indicating floods and a headline announcing a nanotechnology crisis. ILM composited the graphics to the shot.



In addition to supporting flying rigs for the precop actors and stuntmen, the truss supported a gyroscopically stabilized, remote-operated camera that captured wild airborne angles alongside flying performers.

Anderton steps off the train and runs into a squad of hovercops — Precrime officers wearing hoversuits and jetpacks, carrying sick-sticks and a halo. A chase plays out as Anderton runs from the station to an alley, climbs a fire escape and grapples with flying officers as they attempt to apprehend him. Spielberg wanted to shoot as much of the sequence as possible live, with real performers airborne inside real sets. However, based on storyboards and animatics, there was no stage big enough to house the rigging necessary to fly multiple performers through a five-story set. So Alex McDowell built a façade facing Hennessey Street on the Warner Brothers backlot, creating a 30-foot-wide alley open to the sky. Key rigging grip Charley Gilleran then led construction of a 400-foot-long, 50-foot-high steel frame, resembling the skeleton of a warehouse, straddling the set. “It was one of the largest flying trusses anyone has built,” said Michael Lantieri. “It was so big, we had to put a beacon and a flag on it to warn off aircraft! Once the truss was up, I worked with Charlie Gilleran and Brian Smrz to put in I-beams and travelers to support all our hydraulic traveling systems, then Brian started rehearsing stunt people. They could do x/y flying moves with up, down, spin — pretty much everything. At one point, we had two people hovering and six people flying, and we got them up to some pretty high speeds.”

The truss also supported a gyroscopically stabilized remote-operated camera, piloted by Earl Wiggins, capable of capturing wild airborne angles alongside flying performers. Jerry Moss provided dummy jetpacks, which ILM later augmented with live pyrotechnic exhausts. “I like to shoot things for real wherever possible,” stated Farrar. “After Steven had a cut sequence, Scott Frankel and I went through the shots at ILM and analyzed what angles the jetpacks fired from — from the front, the back, the sides, sometimes swiveling past camera. Joe Fulmer rigged a propane burner on a stage here at ILM, and our effects cameraman, Vance Piper, shot a huge library of flame effects. The funny thing was, when Joe popped the fire on and off it created some interesting pulsing effects. Those turned out to be our favorites. So we sometimes took our best-looking elements and manufactured that pulsing digitally.”



Anderton attempts to evade hovercops by scaling a fire escape. Live-action wire work was digitally augmented by ILM artists who supplied CG heat ripple and tracked in live flame elements – captured on stage with a propane burner – to create jetpack exhaust.

Frankel's team tracked and composited fiery plumes to jetpacks and created digital heat ripple, which would become another critical issue. "We had a ton of heat ripple," commented Farrar. "I had never been happy with heat ripple we'd done in the past; so we did heat ripple R&D, looking at Atlas boosters and jet engines." The research showed that chemical ignition created discoloration, so Frankel's artists dialed in subtle tints to visual distortions created during composites.

Farrar shot the majority of flying elements live, with actors suspended from the backlot rig. Pat Jarvis led wire and rig removal, occasionally re-orchestrating action. "Kimberly Lashbrook did an amazing job of the scene where the first cop is flying after Tom," said Jarvis. "The plate was shot with a stuntman coming into frame on wires, but we had to change his angle of approach. Jay Shindell matted out the cop while Lance Baetky and Michelle Gray digitally painted out rigs and wires. Kimberly and I precomped and reconstructed the area vacated by his cutout shape, adding all the puddles and brickwork with parallax effects. Then Kimberly tracked the actor in, gave him a different move, altered his hair, reflected him in the puddle, added jetpack flames and enhanced the lights flashing on his jetpack."

Anderton evades hovercops by scaling a fire escape, but falls and grabs hold of Precrime officer Knott (Patrick Kilpatrick). For angles of performers falling through frame, Barry Armour oversaw the creation of digital set extensions utilizing combinations of photographic textures and paint effects to sometimes double the height of alley buildings and to add 3D fire escapes that are seen flashing by.

Narrowly avoiding impact with the ground, Anderton takes control of Knott's jetpack by grabbing flying controls and propelling himself and the cop up the face of a building, grazing masonry and smashing window boxes. Physical effects team members rigged the wall with fake cement ledges and flowerpots to explode as Cruise and a stunt performer, both heavily padded, crashed through, hauled skyward by cables. The rocket-propelled duo then hurtles up a waste deposit tube — a canvas-covered cylinder used for depositing construction debris — and their jetpack exhaust causes the tube to ignite. The shot was done live.

"Steven wanted to have the fabric burn off, leaving just the skeleton that was holding it," related Lantieri. "I did all kinds of burn tests, starting with cloth and canvas, then moving on to anything that I knew would burn. I didn't want to have any residual burning material fall on the performers, so we ended up wrapping butcher paper around our frame, then painting it to look like canvas. We soaked that in an alcohol-based fire mix to make it burn with a cool flame and not too many fumes, then rimmed the bottom edge with flash paper. The tube was



Anderton leaps from the fire escape and grabs hold of a flying precop, taking control of the officer's jetpack and propelling them both through the narrow alleyway. Though Tom Cruise enthusiastically performed a large percentage of his own stunt work, the piggyback alleyway gag was executed by a stunt performer. Since the double's face was visible in the shot, ILM photographed Cruise after-the-fact and digitally replaced the stuntman's face with his.

approximately 30 feet long. We rigged it in the alley, underneath the truss, and fed our flying cables through that, with cameras all over — one looking down from up top and others on the sides. Brian Smrz connected his stunt people below the tube and then we sprayed the tube with fire mix. We had to go right away before the fumes built up. Effectively, we were pulling Brian's guys through a chimney and we had to time it so the flames were right on their asses. It was fast!"

After capturing the live tube burn, Scott Farrar staged a closeup shoot of Cruise and Kilpatrick to intercut with the live effect. "Tom and Patrick were stationary against bluescreen," explained Barry Armour. "We built a CG tube around them, shot a live flame element from below and added that with camera shake. We also shot a bluescreen element for Anderton and Knott as they graze along the ground. Anderton was too obviously a stunt performer at that point, so we shot Tom with approximately the same angle and lighting, then melded his face to the stuntman. Other than that, they shot it all for real."

The chase continues with Anderton clinging to Knott, piloting the cop's jetpack through a window into a tenement building, startling a family having dinner. Hovercops fly in after Anderton, jetpack thrusters blazing, and hurtle around the kitchen, inadvertently torching food on the stove. Lantieri staged the kitchen flight with hovercops suspended from an inverted hydraulic turntable above the set. Effects technicians sizzled the food by piping propane through the stovetop.

Anderton escapes from the apartment by smashing through the ceiling into the floor above — one of many stunts that Cruise performed himself, closely supervised by Brian Smrz. "Tom is a very hands-on guy," observed Lantieri. "He's very capable, very game and he put a great amount of trust in Brian Smrz, whom he worked with on Mission: Impossible 2. The crashing through the ceiling gag was extreme. We ploughed through a ceiling, crashed into the room above it, hit the dinner table where a family was eating, busted through the table, sent food flying and came out the other side. We did that with Tom and a stunt guy on a wire-pull through breakaway props; but we made sure the other guy was a little taller than Tom, so it was his head hitting the ceiling and not Tom's."



The chase continues inside a fully-automated automobile plant. Lantieri and his crew outfitted the set — built in an abandoned meat-packing facility — with twelve high-end, programmable Kawasaki robot arms used in real automobile production lines. As choreographed by storyboard artists and the CG animatics team at Pixel Liberation Front, the sequence had Anderton battling pursuers on the assembly line as robots construct a car around him.

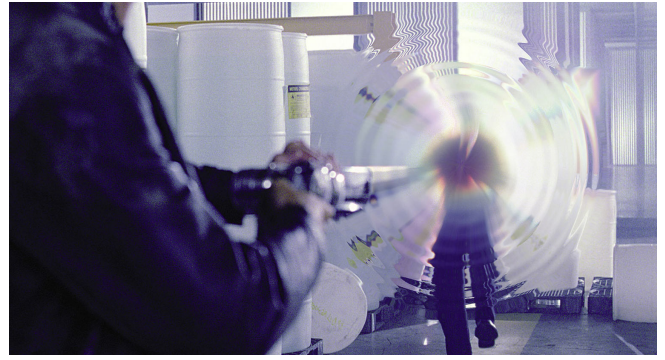
Anderton and Knott burst through the window of the upper apartment, cross the alley and smash into another residence where they tumble to the floor as the jetpack fizzles out. Running from the apartments, Anderton enters an industrial building, followed by Witwer and four federal agents. Spielberg filmed the sequence in an abandoned Farmer John meat packing plant, a cavernous location that provided the setting for a Hitchcockian game of cat and mouse as Precrime agents hunt Anderton amid a robotic automobile factory.

“We started with an empty warehouse,” stated Lantieri, “and we weren’t sure how much we would need to show of the futuristic cars being built. Earlier in production, I had visited New World Motors in San Jose to see how cars were built, and I noticed that they used Kawasaki robot arms in the production line. I contacted Kawasaki and we made a deal to use twelve of their high-end, programmable motion-controlled arms.”

Action for the factory sequence, blocked out by Spielberg’s storyboard artists and PLF, called for Anderton to fight off Precrime agents on the assembly line as robots construct a car around him. Lantieri’s team scratch-built a conveyor belt, overhead carriages and supporting structures braced with I-beams to support the Kawasaki robots. Tom Pahk created custom tooling to fit the robot arms, which gripped car pieces with pneumatic suction. Harald Belker designed and oversaw construction of a custom Lexus car, built in disassembled sections and as a working electric-motor-driven prop by CTEK. To rehearse robotic performance, Lantieri worked with fifteen Kawasaki programmers, who manipulated dummy car parts first in slow motion, then ramped up to sometimes lightning speeds accurate to 1/1000 of an inch. Lantieri videotaped robot rehearsals for Spielberg, covering the assembly in twelve stages, including the frame, body, engine, fenders, seats, roof, wheels and tires.

Alex McDowell’s research also postulated a rapid-prototype-modeling process called stereolithography, whereby computer-controlled lasers cure photosensitive resin, layer by layer, to create solid 3D objects. Lantieri incorporated the process into the production line. Tom Pahk oversaw construction of a stereolithography pool, fitted with a stainless steel screen and filled with tinted methylcellulose. The screen rose from the pool on hydraulics, revealing an automobile shell dripping with syrupy goo. ILM later animated light beams to dance across the surface, simulating laser tooling.

Lantieri’s team provided sparks in great profusion to simulate polycarbon-fiber melding. For shots requiring scalding showers of sparks to rain around Cruise and other players, Lantieri



In the auto factory, Anderton turns a concussion gun on one of his assailants, blowing the man across the floor with the force of the weapon’s sonic blast. Second-unit stunt coordinator Gregg Smrz employed wire-pull gags to stage the live effects of the gun’s blast on set. In post, ILM Sabre artists animated the sonic shockwaves as expanding concentric rings rippling the background.

positioned air mortars to direct hot embers away from the performers, closely watching the action with a finger poised on cut-off switches. ILM composited additional pyrotechnic hits.

Earlier in the fight, Anderton grabs a concussion gun and turns it on the Precrime agents, emitting a sonic blast that blows the men across the factory floor. Smrz staged the effects of the gun with wire-pull gags. Then ILM Sabre artist Rita Zimmerman animated shockwaves as expanding concentric rings rippling the background.



A newly constructed car, with Anderton inside, enters a tunnel where robotic painting nozzles spring into action. Scott Farrar shot a prototype Lexus - dressed with flat-green primer - entering the paint-tunnel set; then ILM employed particle animation to simulate nozzles spraying paint onto its surface. ILM transformed the green to a dull orange digitally, then animated a reveal to a high-gloss version of the vehicle.

Witwer and his men lose sight of Anderton as robot arms bolt a car around him on the factory assembly line. Precrime agents follow the car through its final stages, peering through a window into a bright white room, where robotic painting nozzles spring into action. Farrar shot the paint-tunnel sequence using two versions of the practical Lexus. The first entered the tunnel dressed in flat-green zinc-chromate primer. Rotoscope artist Chris Bayz animated splines to define paint spray jetting from nozzles onto the vehicle's surface and employed Maya particle animation to animate six nozzles — four along the top, two lower at the fender and creeping around the sides. Technical director Michael Ludlam created a color change to orange. Cynthia Hyland composited layers using Zepo to correct parallax and warping as the camera dollied right to left, revealing Witwer at the observation window, paint animation reflected in the glass. Farrar then shot a closer angle of the vehicle undergoing final detailing and drying procedures. "We reverse-engineered that second shot," explained Pat Jarvis. "We started with a deep glossy car and painted it to look dull, removing the sheen at the start of the shot then animating a reveal to the shiny surface. We also had to compensate for the effects of bleach bypass photography, so Scott Frankel did the final composite and color correction, making the flat-matte coat look more tangerine in color. It was just enough to make it look like the car was getting hit with a coat of Clearcoat that stuck magically to only the right parts."

Anderton pops up inside the immaculately painted car, starts the engine and drives off. He next stops at a rural walled estate, seeking the advice of Iris Hineman (Lois Smith), Precrime's reclusive co-founder. Scaling Hineman's garden wall, Anderton tangles with a predatory vine that springs to life and attacks him.

Spielberg shot the plant attack with Michael Lantieri's team moving practical vegetation with monofilament, keeping puppeteering minimal. ILM animator Janice Lew provided digital enhancement, adding extensions to the plant and creating groping tendrils tipped with pointed fronds, which strike at the runaway cop. Reeling from the bizarre attack, Anderton finds Hineman inside a greenhouse, tending more genetically engineered flora. Marie-Laure Nguyen animated an inquisitive nest of baby succulents, and Lew animated a translucent, trumpet-shaped orchid that pesters Anderton.

Hineman provides insights to a possible loophole in the Precrime system — an anomaly that appears when one of the three precogs predicts a contradictory future, through a prevision known as a ‘minority report.’ Anderton resolves to seek out his own Minority Report, stored inside Agatha’s memory at Precrime. To do so, he first attempts to disguise his identity by visiting black market cosmetic surgeon Dr. Solomon Eddie (Peter Stormare), an old nemesis who gleefully suggests an illegal and gruesome eyeball replacement procedure, the only option for desperate fugitives in a world scrutinized by ubiquitous eye-dentiscanners.



Making his escape in the Lexus, Anderton pays a visit to the rural estate of reclusive Precrime co-founder Iris Hineman (Lois Smith), who tends genetically engineered flora inside her greenhouse. ILM built and animated an inquisitive nest of baby succulents, as well as other bizarre and seemingly intelligent plants.

Jerry Moss’ department created specialized equipment for the surgery scene, including a head-hugging, mechanical device that held Tom Cruise’s eyelids open. Filming of the scene was done under the supervision of an on-set ophthalmologist who fastened clamps to Cruise’s lids and applied eyedrops. Black Box Digital provided Eddie’s virtual surgery display, which Kent Demaine created on set as live, interactive playback.

Working in Houdini from photo reference and a cyberscan of Cruise, Black Box artists modeled a translucent 3D slice of the actor’s head from below the eyebrow to above the occipital bone. Animators placed a three-dimensional eyeball into the socket and generated medical graphics in Pinnacle Systems’ Commotion, with text written in Swedish to reflect Eddie’s accent. Hooked up to a liquid-crystal flat screen display, Demaine sat off-camera and operated playback in Macromedia Director, cueing nervous twitches and rotations of the eye to Stormare’s movements as the actor operated a joystick with fingertip controls.

Anderton wakes from his traumatic operation, blindfolded and bedridden, with doctor’s orders to rest for twelve hours. Heavily medicated, he does not notice a Precrime hovership scanning the tenement. The hovership lands in a nearby alley and precops disembark. Spielberg shot the landing using the mechanical hovership rig, transplanted in part to downtown Los Angeles. “We took the cockpit section on the motion base,” said Michael Lantieri, “set it up for a night shoot in an alley on Spring Street, and it barely fit. That was great for selling why this vehicle was so thin, squeezing in between buildings.”

For an angle of the rear of the hovership touching down and disgorging its occupants, Farrar staged the second and final motion control shot in the film. McDowell constructed an asphalt street surface on a bluescreen stage at Universal. Lantieri programmed the hovership interior, lowering its ramp and rotating its wheel. Farrar shot action from below, tilting down with the ship and tracking left to right as precops dispersed, then repeated the move in a plate of the empty Spring Street alley. ILM blended elements, erasing the motion base beneath the mechanical prop, adding the exterior shell around the craft, heat ripple beneath the ship and rotoscoping around the cops as they ran in front of CG ship extensions. The trickiest part of the

composite involved the cop deployment system. “The circular rotating device the guys were sitting on went through the floor,” said Barry Armour. “We had to animate the chairs to fold and flip up into the belly of the ship as they went under and came in contact with the bottom of the alley. That took a lot of work.”

Searching for Anderton, precops identify numerous heat signatures inside the building and land to initiate a ground-level search using eight small surveillance devices — ‘spyders’ — which scuttle from room to room on wiry tripod legs, eye-dentiscanning anyone they encounter. PDI/DreamWorks animated the spyders as completely digital characters, based on art department designs by Mark Goerner. “Steven’s brief was, ‘Imagine Porsche designed a pager,’” remarked Henry LaBounta. “They had to be small enough so the cops could wear them on their belts; then, when they unfurled, they had to be flat enough to get under doors; and if someone was resisting, they had to be able to wrap their legs around that person’s face.” Spyder motion was based on a study by Ryan Roberts, of DreamWorks Feature Animation, which captured the fluidity of movement and intelligence Spielberg was seeking in the creatures. DreamWorks loaned Roberts to PDI as lead animator for the sequence, and he worked with modeler Konrad Dunton to refine a 3D design.

PDI’s early CG model provided the basis for practical spyder props. Property manufacturer Thomas Homsher used the data file to laser-etch a form from plastic, then produced multiple closed versions for actors to wear as weighted metal props on their belts. The shape also became the basis for plastic standing tripods used for blocking and lighting scenes on the four-tiered set. “Steven got right down on the floor with me,” LaBounta remarked, “and while the film was rolling, we moved these little things around like kids with action figures! What better notes could you have than Steven Spielberg moving your characters around? We later scanned frames of Steven with the props, and it was beautiful reference for animation and lighting.”

Spyders deploy legs from their bellies, climb a flight of stairs and scatter through apartments searching for Anderton in one of the most complex camera moves in the film. Designed by Spielberg using PLF animatics, the shot incorporated a 75-second Technocrane move beginning at the ground floor of the set, then tracking back to the fourth story where the camera peered down through apartment ceilings, following spyders room to room. PLF blocked the action with simple spyder models; Alex McDowell then tailored set construction to grip and camera specs.

For animation reference, LaBounta and PDI producer Les Hunter held a pole with a T-joint at one end, a chrome and gray sphere and a plastic spyder prop affixed. Spielberg then shot a pass with the two men running through the shot,



Anderton undergoes illegal and dangerous eyeball replacement surgery, allowing him a chance to investigate – undetectable by eye-dentiscanners – the precog ‘minority report’ that may prove his innocence. Prop master Jerry Moss built specialized equipment for the surgery scene, including ahead-hugging device to hold Tom

puppeteering spyder motions. ILM location matchmove technician John Whisnant helped PDI take measurements of the set, while LaBounta improvised tracking markers for the background plate. “The set dressers dressed down the set by crumbling little bits of plaster and trash across the floor,” stated LaBounta. “I noticed that little pieces of plaster were about the same size as the tracking markers; so we glued them down and measured them, which gave us markers we didn’t have to paint out later.”

PDI tracked the shot using on-set data and plotted spyder animation with color-coded spyder ‘pawns.’ These spyder-shaped blobs allowed Ryan Roberts to focus on gross movements of spyder dispersal, colors facilitating character identification. Roberts then focused on intricacies of key-frame animation. “If the spyders moved really fast,” said LaBounta, “their legs completely went away in motion blur. So we ended up adjusting motion blur on a per-shot basis. They were completely key-frame-animated. We wanted to show that they had intelligence and the ability to communicate.”

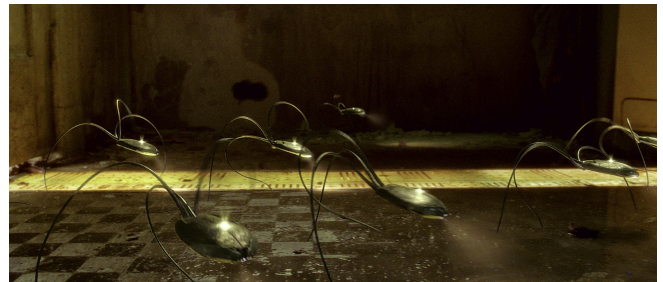
Lighting supervisor David Blizzard added an activation light to the top of each spyder carapace and animated scanning beacons in front, which helped the tiny robots to read against the dimly-lit backgrounds. To assist in wrangling the enormous render data for the lengthy shot, CG supervisor Eric Bruneau made use of a natural wipe in frame, as the camera passed close by a wall, to split the shot in two, then reassembled the shot to its 1803-frame length.

Anderton hears the commotion caused by the spyder invasion, blocks the gap under his own door, then leaps into a bathtub of iced water to disguise his heat signature. The spyders, undeterred by the sealed door, gain access through the ‘healthflow’ system — a glowing sewage drain lining corridors and rooms, rigged underneath the set by the physical effects team, which puppeteered removal of a translucent healthflow tile using monofilament. PDI animated spyders to manipulate the tile and proceed beneath the floor.

Once inside the seedy room, one spyder slips under the door to the bathroom, where Anderton is hiding. Cruise was filmed by underwater cameraman Pete Romano, and performed submerged scenes by holding his breath, lying in an oversized bathtub partially filled with dummy ice, topped off with the real thing. “Tom could hold his breath for a minute-twenty!” declared Les Hunter. “People became concerned he’d been under so long; but then he’d lift his arm and tap his watch as if to say he still had time to go.”

The spyder is about to depart when a tiny bubble escapes Anderton’s nose. Seven other spyders instantly swarm into the room, climb up on top of the tub and peer into the water. Composer

Cruise’s eyelids open. Filming was done under the supervision of an on-set ophthalmologist.



Precrime searches the tenement building where Anderton recovers from his illicit surgery, deploying small surveillance devices called ‘spyders,’ which scuttle from room to room eye-dentiscanning anyone they encounter. PDI/DreamWorks artists created the digital spyder effects, basing their model and CG-animation on production art department designs. In keeping with a Steven Spielberg directive, the spyders were animated to move with grace and a sense of intelligence.

Erik Winqvist created subtle ice animation for a shot of the first spyder appearing over the edge of the bathtub where, probing for a foothold, the tiny robot nudges an ice fragment aside. Winqvist reverse-engineered the effect, painting out a live cube at the beginning of the shot, pasting the ice into the spyder's path, then animating it to slide to its original position. Romano shot reference of a prop spyder on the bathtub seen from underwater. Lantieri dropped a tiny pellet into the water to simulate a spyder experimentally dipping its foot. PDI digitally erased the pellet and its stream of bubbles, then added spyder animation rippling through the water and composited a zap of light as the spyder tapped its foot, combining a live pyrotechnic flash shot against black to amplify the effect.

Stung by the electric shock, Anderton erupts from the water and submits to spyder scrutiny. The sequence called for intricate rotoscoping of water drops cascading around the spindly robots. To add drama and minimize motion blur for the PDI roto team, Janusz Kaminski set the camera shutter at 45 degrees, isolating water droplets in midair. The presence of a grimy mirror behind the bathtub also required a composite trick to place spyder reflections behind the layer of grime. LaBounta and Hunter rigged a sheet of black duvetyne to reflect in the mirror, photographed the texture and composited with renders of spyder animation matted into place.

Eric Bruneau also added spyder reflections to wet bathtub surfaces and cast reflections of light to ripple over spyder bodies. David Allen produced interactive effects as water splashed onto the tiny robots. "Little beads of water very quickly ran off the spyders' alloy surface," commented LaBounta, "but they pause and gather at the edges before they drip off. It was procedural animation with key-frame control. We controlled the number of drips and where drips should start; then they procedurally ran along the surface based on the tilt of the spyder. That kind of subtlety really added to the realism."

Closeups of the spyders interacting with Anderton revealed their mechanisms in full detail, including a complex understructure that suggested organic life. "Steven asked for gears or machinery moving underneath," said LaBounta. "I'd recently visited Monterey Bay Aquarium and had been very impressed by the deep-sea jellyfish with their fabulous iridescent lights. It wasn't exactly what Steven had asked for, but they inspired



The spyders locate Anderton, who has submerged himself in icewater in a vain attempt to avoid detection by the heat-seeking devices. Data files from the PDI spyder model were used to laser-etch a plastic mold from which practical replicas were cast. The nonarticulated props, carried by precop actors during the shoot, were also useful for lighting and scene blocking, enabling Spielberg to choreograph desired spyder action on set.



A spyder directs a scanning beam into one of Anderton's partially healed eyes. In addition to compositing the CG laser beam, PDI reflected the spyder laser in the eye and animated a color change to blanch Anderton's irradiated iris. The closeup shot also revealed spyder operating mechanisms, including a complex, organic-looking under structure of gears. Artists based the spyder under belly look on jellyfish.

me; so we created a few versions, showed them to Steven, and he really liked them. We made them pulse through a spectrum like a little heartbeat.”

Poised in front of Anderton’s face, the lead spyder reveals a tiny parabolic mirror beneath two pinball-flipper-shaped cowlings in its nose. The mirror’s reflective moiré pattern focuses an eye-dentiscanning laser beam, causing agony for Anderton in one partially healed eye. Erik Winqvist composited the CG zap, reflected the spyder laser in the eye and animated a color change to blanch Anderton’s irradiated iris. David Blizzard dramatically toplit the scene, creating Dior filter light-bloom effects by cloning practical light sources and layering them into the animation, then utilized a hybrid global illumination approach to calculate ambient light levels with radiance maps. Cyber F/X paid a set visit to capture cyberscans of Cruise during the star’s busy schedule. Blizzard used the data to model spyder shadows on Cruise’s face and bounce flesh tones onto the subtly scratched and dented spyder alloy.

Intercut with precops surveying Black Box screen displays — composited into hovership controls by PDI — the spyders fail to identify Anderton and retreat, concluding a 37 shot sequence, the last that PDI/DreamWorks would undertake as a visual effects facility before focusing entirely on CG animated features. “We were excited to work with Steven, and we would have liked to continue the relationship down the road,” Les Hunter. commented. “That still might happen in the studio’s future. Until then, we’d like to think that we went out on a high note.”

Anderton exits the apartments wearing dark glasses to disguise his cauterized left eye — a contact lens effect designed by KNB EFX, created by Dr. Jonathan Gording and applied by lens technician Sean Kenney. Arriving at Precrime headquarters, Anderton uses an air syringe supplied by Eddie and injects himself with a paralytic enzyme, causing his face to slough temporarily into an unrecognizably withered version. “We gathered a lot of photo reference of wrinkled and elderly people,” related Scott Farrar, “then Mark Casey created a Sabre composite of all those faces, tracked to Tom’s face. The breakthrough for me was realizing that, as Tom leaned forward in the shot, his whole face needed to sag as the gravity angle changed. We made one side of his face appear to droop, and it looked extremely realistic.” Casey produced distortions using ‘Squizz,’ a Photoshop brush tool that allowed him to drag and smear pixels of the actor’s face, pore by pore, morphing and distorting features to sag.

The final stage of the transformation matched to a full-face prosthetic makeup designed by KNB in collaboration with makeup supervisor Michele Burke-Winter. Garrett Immel created clay sculptures of the makeup with input from Cruise, then Camille Calvet applied the foam gelatin prosthetics. KNB also supplied a pair of gelatin dummy eyeballs — replicas of Cruise’s own — for shots of Anderton’s fumbling attempts to use them to eye-dentiscan his way into the high-security building.

Anderton’s facial features restore inside the precog temple, where he frees Agatha by flushing her precog tank and escaping with her through a drain. Tom Pahk engineered and triggered the tank draining effect with a hydraulic flushing mechanism that evacuated two stunt performers and 4000 gallons of liquid into an ejection tube.

Anderton and Agatha speed away in the waiting Lexus, paying a visit to Rufus T. Riley's Dreamweaver Headspa, a cyberparlor where patrons lounge in virtual reality cubicles sampling mental images ranging from extreme sports to less salubrious activities. Black Box created animation for the entry to the cyber-parlor, providing swooping aerial views of the Grand Canyon and underwater shots swimming with dolphins. Matthew Morrissey rear-projected imagery onto fabric screens placed around the set. Black Box also warped video in Flame to map inside personal virtual reality cubicles, which Morrissey rear-projected from groups of Barco projectors. "Rufus' clients pay their money, sit in these rigs, put on the masks and see three-dimensional worlds around them," said Farrar. "At one point we thought rear projection would work for all of those scenes, but they tended to look like rear projection; so we ended up doing a lot of tricks to make them look more 'hologrammy.'"

Along with downhill skiing and a solarized lap-dancer rave, the virtual reality cubicle sequence also included an 'adulation scene' featuring screenwriter Scott Frank as a cyberparlor client who receives kudos from tuxedoed gentry. Farrar directed the greenscreen elements and applied visual tricks to create holographic looks. For the adulation fantasy, he shot repeat takes of hologram performers grouped in various configurations, the camera pushing in as they adulated a tracking marker ball. Michael Gleason assembled footage as a series of rough Avid composites, eye-matching camera moves and overlapping dialogue to create a mishmash of sound similar to a Frank Zappa Mothers of Invention recording. Sabre artists matted translucent characters into the booth and slipped in a hazy 2D background of the Royal Albert Hall.

Seeking the Minority Report that may prove his innocence, Anderton strong-arms Riley (Jason Antoon) and convinces him to hack into Agatha's subconscious. Riley connects the precog to illegal hardware and unleashes a flood of disturbing imagery that appears on a monitor covering one wall. Spielberg shot his actors reacting to a bluescreen panel. Asylum tracked shots and composited imagery into roving camera moves, keying through Dior lens flares, sometimes simply adding black to the deactivated screen. Imaginary Forces supplied prevision footage. "Anderton has to sift through every prevision this woman has witnessed since she was nine," stated Matt Checkowski. "It was all going to flash by so fast we decided to shoot on high-definition video. We had one long day with second unit at the Ambassador Hotel in Hollywood, shooting this litany of murder. We had guys being stabbed, people being tortured, people being strangled. We felt terrible afterwards. Our karma was out the window."

Instead of providing the alternate vision of the Crow murder Anderton seeks, Agatha's prevision reveals a further glimpse of Ann Lively falling prey to a hooded figure in a lakeside setting. Spielberg shot the scene at Franklin Canyon Lake in Los Angeles, using Imaginary Forces' visual language of repeat takes and disjointed angles, and improvised a Jean-Cocteau-style reverse-action photography effect to further skew perspectives.

Precops burst into the cyberparlor, leading Anderton and Agatha to exit through a back door and run out into a shopping mall. In the confusion, Anderton collides with a businessman who spills a briefcase containing animated Playboy, People and U.S. News magazines — the latter displaying Anderton's face against a ticking clock beneath the graphic "Countdown to Murder — Precrime Cop On the Run." Farrar shot the briefcase spilling three white cards, onto which Ricardo Torres tracked and composited Black Box graphics, creating a high-contrast color burn to simulate the look of animated ink. Torres warped shapes to flop realistically, added a spectral sheen keyed from a real magazine coated in black plastic, and composited the magazines to fall and fan with motion blur.



To enter Precrime headquarters unrecognized, Anderton injects himself with a paralytic enzyme that temporarily disfigures his face. Though a transition scene was achieved digitally by ILM, KNB EFX Group created the full-face disfigurement makeup, which consisted of gelatin prosthetic pieces. The company also built a pair of fake eyeballs, replicas of Cruise's own, for shots of Anderton attempting to use them to eye-dentiscan his way into the high-security building.

Agatha utilizes her powers of precognition to help Anderton evade their pursuers with split-second timing, ducking the police amid giant flashing holographic commercials designed by 3 Ring Circus, executed by View Studio and Base 2 and composited by Asylum. To counterpoint the foot-chase, a huge Reebok ad looms behind Anderton and Agatha as they pause amid the crowd. View Studio created the eerie image — white-on-white alien figures running through a Tron-like stadium — by photographing runners wearing bluescreen bodysuits against greenscreen backgrounds and mapping faces in Realviz Image Modeler.

Nearing zero hour in his rendezvous with Leo Crow, Anderton stops in his tracks as visual clues from the Crow prevision begin to manifest inexorably before him. A Revo advertising billboard points the way to a hotel. A broken room number takes him to an upper-floor room. Against Agatha's advice, Anderton confronts the man he is meant to kill. In pure Philip K. Dick tradition, the paradoxes play out only to result in Anderton shooting Crow point blank. Farrar filmed the live-action pyrotechnic effect in front of a bluescreen backing at the first-floor window of the Los Angeles location, then inserted the Revo billboard digitally against a still of the facing buildings.

Anderton flees with Agatha, seeking refuge at his family's summer cottage in Chesapeake Bay, now the home of his ex-wife. Moved by omnipresent reminders of Anderton's son, Agatha experiences an emotional reawakening and — cradling her animated datacard — begins to reveal her own memories of Ann Lively, her mother. Before she can continue, two hoverships appear, one cutting a wake as it skims Chesapeake Bay. ILM provided digital flying vehicles, tracked into an aerial plate of the Virginia home. A speeding Jet Ski — later removed by ILM compositors — provided live wake imagery. Smrz and Lantieri staged precops lowering from the descender rig on location. ILM painted out the rig, repositioned stunt performers and affixed descender ropes to the CG hovership.

Anderton is then apprehended, his head shaved and a halo clamped to his scalp as he is placed into a tube in the Department of Containment. Farrar filmed the insertion scene in reverse. "It was easier to take Tom out of the sled than it was to put him in," commented Dana Friedman, "so we shot the scene backward with the camera upside-down, then flipped the negative so the shot appeared to run forward. The only problem was that Gideon had some dialogue, so Mark Casey digitally removed the actor's head, ran that part of the footage in reverse so the lip-sync worked, then tracked his head back onto his body."



Anderton gains entrance to the precog chamber and absconds with Agatha, whose brain, he unwaveringly believes, must hold a suppressed prevision that will prove his innocence. Samantha Morton, Steven Spielberg and Tom Cruise prepare for a cyber parlor scene in which Anderton — his facial features restored — hacks into Agatha's mind through the use of bootleg Precrime hardware, unleashing a flood of prevision imagery that appears on a wall monitor. During the live-action photography, Cruise reacted to a bluescreen panel, onto which Asylum tracked and composited Imaginary Forces imagery.

Anderton's wife begins to suspect Lamar Burgess' involvement in her husband's incarceration and takes matters into her own hands. During a gala celebrating Burgess' appointment as the head of Precrime's new national law enforcement division, Burgess receives a phone call from Anderton, and Agatha's prevision of Ann Lively's murder begins to play on giant screens around the ballroom.

Asylum tracked and keyed the prevision into floor-to-ceiling bluescreen panels on set, occasionally trimming onlookers' frizzy hairdos, then pasting hair back onto heads, when keying was not possible. The prevision finally reveals Burgess as Ann Lively's masked murderer — images selectively culled from Imaginary Forces' two-and-a-half-minute sequence — and Burgess hurries to escape the ballroom.

Back at Precrime, Agatha and the precogs trigger a redball alert, identifying Anderton as victim and Burgess as murderer. Anderton intercepts Burgess in a standoff on the hotel terrace, filmed on a rooftop set with a half-scale model of the adjacent building and a bluescreen backing. ILM inserted three tiled plates of nighttime Washington D.C. to the bluescreen element and added a CG moving point of light of an approaching hovership. Burgess points a gun at Anderton, until the hovership appears — inferred by off-screen lights and wind effects with another live descender gag — signifying the end of Burgess and the Precrime system he created.

In a quiet coda, Precrime stands deserted, its precog tanks empty, while Anderton relaxes in his apartment, reunited with his wife. Arthur and Dashiell, meanwhile, sit reading, with Agatha nearby, staring out of a window, happy to be free, far from their de facto prison and the terrifying visions that have haunted them all their lives. The film closes with a five-and-a-half-minute pullback, composited by ILM, revealing the precogs inside a cabin on a secluded island at twilight.

"We did the last shot in two pieces," remarked Barry Armour. "Steven shot a crane move tracking out of an interior cabin set with a bluescreen window. We did a rough matchmove on the shot and derived an animatic from that. Then Scott took a videotape of the animatic with him on a helicopter shoot of The Island, which was off the coast in Maine." Farrar laid out the dimensions of the cabin on a clearing on The Island, placed markers on the ground, then attempted, with director of aerial photography Larry Blanford, to match the original pullback shot. Digital modeler Frank Gravatt later created a 3D tractor and cabin, which digital model painter Tony Sommers hand-painted from photo reference. Technical director Patrick Neary and compositor Barbara Brennan matched the bluescreen interior to the helicopter plate, blended the two when the wall of the CG cabin filled frame, and tweaked sunset hues to create a sense of aerial perspective.



At the cyberparlor, patrons lounge in virtual reality cubicles, where they experience, vicariously, anything from extreme sports to lap dances to unbridled adulation. Black Box Digital animated the cyberparlor scene imagery, which was rear-projected onto fabric screens placed around the set. Digital enhancement disguised the tell tale artifice of rear projection and infused the imagery with a look that was more in keeping with that of a hologram.

“After about 2200 frames, it was no longer possible to see perspective changing on the house,” said Armour, “so we rendered the cabin as a still-frame from there on, keeping our particle animation going of the smoke coming from the chimney. That made it a little easier to handle. We then did several versions for international releases, with different language credits appearing over the shot. It was a tricky film-out. Try getting a clean negative several times for 8000 frames!”

The action-packed, 75-day shoot and nine-month postproduction for *Minority Report* represented a hefty project for all — involving 261 ILM shots, 37 PDI shots, 27 minutes of *Asylum* composites and 275 Black Box Digital screen graphics. Technical complexities were universally demanding. “We had a tremendous amount of paint and roto work and two-dimensional compositing,” Scott Farrar concluded, “and we spent a lot of time on backgrounds, adding flares, shaky-cam, vibration and helicopter moves, deriving the look from aerial plates shot on a hazy, backlit, crummy-looking day. Whatever the grain was in the background, we put that same grain into every other element — CG, animation, even bluescreen elements of Tom Cruise when he was in the shot. All those things made the shots look more real, as if we had photographed them on location. We put a lot of effort into trying to be aware of what real photography would be in these new and varied circumstances.

“That was what I enjoyed about working with Steven. He looks at everything in terms of what the camera really sees — what would a real lens do, what would it photograph like on film? I come from a photographic background myself, so it was very easy to talk to him on those terms, discussing the art and the design of the shots and how to make them look real. That’s what drove the technique. It was totally creative and organic.”

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Despite his efforts to redirect his fate, Anderton finds himself in the exact circumstances predicted in the prevision — in a hotel room, preparing to execute the man claiming to be his son’s kidnapper. The climactic scene was shot on location in a first-floor room, made to look like an upper-story suite with ILM’s digital compositing of an advertising billboard on cables and still photography of buildings in the windows.

Building a Better Pug

image

ARTICLE BY BRAD MUNSON

Men in Black the surprise smash hit of 1997, was such an unequivocal financial and critical success, a sequel seemed all but inevitable. But director Barry Sonnenfeld, Sony Pictures executives and all other interested parties agreed that a second *Men in Black* project would succeed only if virtually everyone from the original production, both in front of the camera and behind, signed on.

creature designer Rick Baker and the visual effects team at Industrial Light & Magic — producers Walter Parkes and Laurie Macdonald spent a full year just trying to put the deal together. Finally, after months of effort, they commissioned *Galaxy Quest* screenwriter Robert Gordon to pen a script compelling enough to attract that core group to *Men in Black II*. The ploy worked — everyone returned, with the exception of ILM visual effects supervisor Eric Brevig, who was already committed to other projects. Fellow ILM supervisor John Berton stepped into Brevig's shoes.

With his core team on board, Sonnenfeld brought in screenwriter Barry Fanaro, with whom he had worked on *Big Trouble*, to rework Gordon's script. The screenplay continued to evolve throughout production, but the basics of the story finally emerged in summer 2001.

Five years have elapsed since the end of *Men in Black*, when a weary Agent Kay (Jones), a senior officer in the super-secret alien-control organization, volunteered for memory-erasing neuralyzation and a more normal life. Now Agent Jay (Smith) — once the rookie — is the hardened veteran. The agents team up again when a 25-year-old menace rears its ugly head in the form of Serleena, a wormy alien shape-changer. After searching the galaxy for the precious Light of Zartha — supposedly sent away from earth in the 1970s — Serleena returns to claim it, disguised as a scantily-clad Victoria's Secret model (Lara Flynn Boyle). Aided by the two-headed Charlie and Scrad (Johnny Knoxville), she interrogates, then kills the Zarthan emigrant Ben, who confirms that the Light remains on earth and will destroy itself and the planet if not returned to Zartha within hours. Ben's murder is witnessed by his friend and surrogate daughter, Laura (Rosario Dawson).

Discovering Serleena's plot to steal the Light, Jay also learns that the currently amnesic Agent Kay may be the only one who knows where it is hidden. Now a postal worker in a small Massachusetts town, Kay is retrieved and deneuralyzed; and he and Jay follow a trail of clues that Kay, in his former MIB life, left behind to locate the Light and keep it out of Serleena's clutches. When Serleena ups the ante by kidnapping Laura and taking over MIB headquarters, Jay and Kay join forces with the Worm Guys and Frank the Pug to rescue the girl, get MIB back, return the Light to Zartha — in short, to save earth from the scum of the universe, one more time.

Like the original, *Men in Black II* was ambitious in its slate of digital, practical and creature effects; but even so, Sony Pictures wanted it completed in a fraction of the time the same team had been given to produce the first film. Work had to begin immediately, starting with the design of hundreds of aliens to inhabit the singular world of the men in black. To brainstorm those alien designs, Sonnenfeld once again turned to Rick Baker, who did his design work primarily in Photoshop, not only imagining concepts for Serleena and other major characters, but also designing generic aliens that would be seen in MIB headquarters, in Kay's post office and on the streets of New York. As before, Baker and his Cinovation Studios team collaborated closely with Bo Welch, making sure that his designs conformed to the production designer's overall plan and the established *Men in Black* style. "I think we all found it easier to do this film," Baker remarked, "because we had a real trust for each other. Barry knew I had delivered what I said I would in the first picture, and I knew he'd do a great movie this time."

While Baker directed his efforts toward alien design, the script continued to evolve and change — sometimes dramatically. The opening title sequence, in particular, went through a number of significant revisions — from a sequence following a tour bus through Manhattan, to one involving an elaborate underwater assault by the MIB on a submerged alien city, to the camera following the flight of a firefly through the streets of New York, a scene reminiscent of the dragonfly opening of the first *Men in Black*.

Although props and sets had been built and photography undertaken for some of these potential sequences, Sonnenfeld finally settled on opening the movie with a clip from a fictional — and very bad — 1970s television show, *Mysteries in History*, hosted by Peter Graves. The tacky program, with its Ed Woodian production values, not only provided an appropriately humorous setup, it reintroduced the world of *Men in Black* and provided crucial exposition regarding the Light of Zartha.

The title sequence begins as the live-action clip ends, with a nonfictional spacecraft — a better-looking version of Serleena's ship as seen in the TV show — zooming through the galaxy, blowing up planets along the way, presumably just for the fun of it. The all-digital 'Destroy All Planets' sequence was developed so late in the schedule, ILM — already burdened with a full effects slate — could not take it on. Sony's own Imageworks, under senior visual effects supervisor Ken Ralston, stepped in to produce the sequence with only eight weeks left in the production schedule.

Ralston's primary goal was to make the sequence distinctive. "What I really need to do at this point in my career is blow up another planet," Ralston quipped. "I tried to come up with some unique, stylized versions of planet destruction — all within the limitations of what Barry wanted." Ralston's ideas were refined in concept renderings by Robert Stromberg, which illustrated no two planets expiring in quite the same manner. "It was fun to come up with some cool and different-looking ways these things could come apart. One planet is electrified; one shatters like a glass ball; one melts down like lava; and one implodes — it cracks apart and is sucked into its own center. Then it starts to pull in the moons around it, and the whole thing goes to a white-out explosion — and a couple of title cards emerge from that. The title cards

were an important aspect of how we composed shots and how we lit them. We had to make sure audiences would still be able to read the title cards, no matter what was going on behind them.”

Another consideration in designing the title sequence was the sight gag that would come at its conclusion, when Serleena’s presumably massive, planet-destroying spaceship is revealed to be only a few inches tall. “The entire opening was deliberately designed so that you wouldn’t be able to tell how big the spaceship was,” Ralston affirmed. “We had to create the sense that this was a very large ship. And then the joke is revealed when the ship lands in Central Park and a dog comes over to it — and towers over this very small spacecraft.” Originally intended to be quite short, the title sequence grew to a lengthy four minutes — all one continuous shot — when Sonnenfeld responded favorably to the delivered images.



Despite the success of *Men in Black*, director Barry Sonnenfeld was loathe to delve into a sequel unless he could reassemble all of the original’s major participants. Four years passed before the salary demands and conflicting schedules of that creative team meshed, allowing for the start of production on *Men in Black II*. Sonnenfeld on the set with actors Will Smith and Tommy Lee Jones, reprising their roles as Agents Jay and Kay.

The title sequence is followed by the ship’s plowing into Sheep Meadow in Central Park. The live-action for the rough landing was shot at the real location by ILM second unit director Michael Owens. “Michael shot backgrounds of the New York City skyline,” said John Berton, “which we then enhanced digitally to draw out different parts of the city that we wanted to see. Since they were going to work as backdrops, we wanted to make them more beautiful and scenic. That digitally enhanced footage gave us our back layer.”

The ship itself was a model, shot by Michael Owens on a Central Park set at Sony Pictures Studios in Culver City. “It was a full-sized set with respect to the movie,” said Berton, “but it was shot as miniature photography in order to create the illusion for the audience that this ship is enormous — until the dog appears on the scene. So that shot had a live-action, full-size New York background with matte painting enhancements, live-action from Central Park, a miniature set shot high-speed, and a computer graphics spaceship, followed with a model spaceship. All those things were put together using digital compositing techniques to create the illusion we were after, which was the discrepancy between the perceived scale and the actual scale.”

Moments after the spacecraft lands, it spits out a tiny CG creature from its pointy end. It is our first glimpse of Serleena in one of her many forms, this one being the ‘neural root,’ a greenish worm-thing, no more than three or four inches long, with a bulbous head that looks like an artichoke. In the course of the film, Serleena would shape-shift into a tangle of worms, the Victoria’s Secret model — capable of growing an endless supply of eel-like extensions from her fingertips — and a huge wormy monster as big as a skyscraper.

Both Baker and ILM art director David Nakabayashi contributed designs for Serleena in each of her incarnations. Collaborating with ILM conceptual artists, Nakabayashi commenced working on the Serleena creature at the project's inception. "The trick," recalled Nakabayashi, "was to give the Serleena creature continuity, even though it would be seen in many different forms. There had to be visual cues telling the audience that Serleena was one creature."

At Sonnenfeld's suggestion, the ILM artists started with the idea that Serleena was essentially a plantlike organism. "We envisioned it as something that might grow in the way a thicket grows," Berton commented. "Some of the ideas we tossed around as inspirations were the ways in which the dragon in *Sleeping Beauty* ensnares Prince Charming — not literally, but as an idea of how a dangerous creature would ensnare the agents of the MIB, using a terrible, growing thing. We did a lot of work along those lines."

ILM designers, modelers and software developers had been developing the thicket or 'bramble' idea for a full six months when Sonnenfeld decided to change Serleena from a thorny, plant-based creature to something more meaty and organic, like worms or eels. "The bramble didn't seem to have enough intent," remarked Berton. "We didn't want it to seem as if the monster was just growing like a plant, but rather as something that had purpose. So, at that point, the creature turned into something that was more like snakes."

"I think the change was a very good one," said Nakabayashi. "Going from plants to something that was more like an animal was much more scary. It created an 'eew, I don't want to touch that, and I don't want that thing touching me' response from audiences. And even though the change came very late in *The Game*, our software guys were able to make it work."

Serleena's new eel look, which required a complete redoing of model geometry, textures and animation, is hinted at in her first appearance as the neural root, an ILM design and computer



Men in Black II opens with the landing of a spacecraft in New York's Central Park. A model ship was framed and lit to disguise its diminutive size, the gag revealed only when a curious dog enters the scene.



A 'neural root' – the first of several forms taken by the villainous Serleena – emerges from the ship. Lead effects house Industrial Light & Magic, under the guidance of visual effects supervisor John Berton, realized the CG creature.

generated character. For reference in building the neural root CG model, ILM modeler Sunny Wei looked at artichokes, pine cones, a seed pod from a magnolia blossom — anything that had the quality of overlapping petals that could open up and flare out in the way the neural root would when threatened by the dog.

“Once we had some artwork that sent us in the right direction,” noted digital model supervisor Ken Bryan, “Sunny built the model flattened out, then wrapped it around a rig that allowed us to control it, open it up and let the animators animate it. It was a complicated model with many parts that had to overlap each other, and he didn’t want them to penetrate whenever it did open. It was much easier for him to control things in a flat plane — though it was still stacked up three-dimensionally — than to have to figure it out while it was in its final form.” Viewpainters, who work in a 3D paint platform, painted the folded-up, 3D version of the creature.

To up the ‘eww’ factor, Sonnenfeld wanted the neural root creature to look as wet and slimy as possible, an effect that was achieved with shaders.

“We ended up doing what we called our ‘gel pass,’” stated associate visual effects supervisor Erik Mattson, “which was a separate slime layer that sat on top of the actual model. For reference, we grabbed an artichoke head from the supermarket and dumped various semi-thick liquids on it: shampoo, mineral oil. That was our best guide as to how the thing should look.”

The slimy neural root was finally composited into the live-action background shot in Central Park — although much of that location footage was ultimately replaced with digital imagery. “The background plate was shot with a real camera, which had a depth-of-field limitation,” Mattson explained. “We rendered a new background and put digital rocks in the scene so there would be perspective changes as the camera moved. We made a matchmove based on the original plate, and then we had our matte painter, Jonathan Harb, make a photograph of the new element, and put that into the image. That allowed us to have complete control and flexibility, and it was much simpler than working with an existing plate that they had shot with only a slight idea of what was going to happen in the final shot. By the end, the original plate was more like a reference photo than a live plate.”

The neural root then transforms into Lara Flynn Boyle in black lace lingerie, an effect originally conceived by Rick Baker, who drew a number of illustrations showing the creature’s roots growing and wrapping around themselves to create a female human form. “It looked as though there was a clear shell of a woman,” said Baker, “and this root was growing inside that shell. Eventually, the roots got so tight it started looking like skin.”



The neural root transforms into a mass of slithering worms, also created digitally at ILM. Throughout most of production, the Serleena creature had been envisioned as plantlike, so ILM directed its R&D efforts toward achieving a look suggestive of brambles. Late in *The Game*, however, Sonnenfeld revised the concept, shifting to worms as a means of endowing the creature with a greater appearance of intelligence and intent.

Baker's initial notion had evolved into something else by the time the transformation effect was finalized at ILM; and, as it appears in the film, the transformation is completed in only two shots. The first is an all-CG image of the neural root as it sprouts an endless array of moving, wormy tentacles. Cut two starts on a magazine page showing the Victoria's Secret ad that inspires Serleena to take her new form — a practical element with a specially produced photograph of Lara Flynn Boyle in Victoria's Secret attire, achieved with the assistance of an actual Victoria's Secret photographer. The camera then slowly pans up Boyle's body, catching the last of the transformation in her head area as the worms weave themselves into a pleasing shape.

"As we travel up her body," noted animation supervisor Tom Bertino, "we catch up to the worms as they are finishing their job, weaving into her final shape. At the beginning, when the worms first start coming out, they are various thicknesses; but by the time we get up to her face, they have become so small, so thin and so uniform they're like a pot of angel-hair pasta. All of these worms — which exist in 3D space — have some portion of her facial coloring or texture on them. There would be a little bit of her lipstick here, a little of the mole on her cheek over here, a little rouge over here. Some of this texture and color was taken from the actual photograph; some of it was touched up by hand. We had to break up all of that photographic texture so that when the eels came together, there was the feeling that if those pieces really came together, it would form her face."

To make a smooth transition from the effect to the image of the actor, ILM's digital model crew had to build a digital Lara Flynn Boyle in her negligee, matching her pose and facial expression in the live-action plate precisely. The CG model was based on a full-body cyberscan of Boyle. "We also had a very detailed closeup head scan," said Ken



Inspired by a magazine ad, Serleena assumes the guise of a lingerie model. ILM accomplished the fluid transformation from CG worm mass to CG Lara Flynn Boyle to the actress herself.



Accosted by a mugger, Serleena eats her assailant whole, leaving her with a grossly overstuffed belly — a foam latex appliance built by creature designer Rick Baker and his Cinovation crew.

Bryan, “because we knew we’d be doing other effects shots that involved her face. We built her in a relaxed pose, then had her matchmoved into the proper stance. After that, we adjusted the model frame by frame to make sure it was lining up exactly with the actor in the plate. It couldn’t be off even a pixel.”

Serleena has taken on her human form fully when she is attacked by a New York mugger and, nonplussed, swallows him whole. Though the actual ingestion takes place off-screen, we see the results of Serleena’s meal when she emerges from behind a bush with a huge, overstuffed belly. The belly was a foam latex appliance created at Cinovation — actually, created more than twice to accommodate changes in casting and design. The casting switch came when Famke Janssen — originally cast as Serleena — left the production just a few days into principal photography due to an illness in her family. The belly created for Janssen was unsuitable for Boyle, because the two actresses were significantly different in size. Like the original, the rebuilt belly was an appliance that Boyle was zippered into. “Fortunately,” Rick Baker noted, “we had the advantage of the bra and panties to hide seams and zippers.”

Additional versions of the belly were also created in response to changing concepts. Early Photoshop designs had illustrated a relatively subtle effect; but Sonnenfeld urged Baker to make it bigger. “He kept saying, ‘I think it should look more like my fat stomach,’” Baker recalled, “and so we ended up doing one like that — a really fat thing that hung down over her panties. But then, when he saw it, Barry said, ‘Oh, no, that’s too much.’ So at the last minute, we had to go in and hack big chunks out to make it smaller.” Like the bulimic models she is emulating, Serleena retches behind a bush and reemerges with her stomach once again lingerie-model flat.



In search of the precious Light of Zartha – hidden on earth – Serleena enlists the aid of a two-headed alien named Scrad and Charlie. Johnny Knoxville played both characters. As she does throughout the movie, Serleena extends snaky tendrils from her fingertips – an ILM digital effect – to secure the cooperation of her dimwitted minion.

Serleena is not the only alien in town. Across the city, Jay and his rookie partner Agent Tee (Patrick Warburton) are talking tough to a little flower poking out of a sidewalk steam grate. The flower seems to be an unlikely target for the MIB agents’ abuse — until it rises up out of the ground and reveals itself to be the topknot of a 600-foot-long worm creature named Jeff. “The flower is typical of what we see in the world of the MIB,” stated ILM visual effects producer Ned Gorman. “Nothing is what it appears.”

The massive worm that rises majestically out of the steam grate was the result of a creature development process that began in the early days of preproduction and did not end until Christmas 2001. After Rick Baker’s contributions, and a maquette sculpted at Cinovation by Matt Rose, Jeff’s design continued to evolve within David Nakabayashi’s creature group, with sequence supervisor Amelia Chenoweth producing a number of concepts. For reference, the design group looked at a variety of funny-looking, stubby forms, including tomato worms. “There was quite a bit of drawing and exploration done,” said Chenoweth. “One of the key

things in the design was the powerful mouth on Jeff the Worm. He had this incredible mouth with giant, rotating teeth that went back in concentric circles.”

Jeff was also designed to glow with a kind of bioluminescence. “Barry had always wanted this thing to glow,” observed Chenoweth, “because that glow works as a kind of camouflage for Jeff. There are shots in the movie where you see a subway car go by, with its windows illuminated; and then you see the worm go by — and the worm resembles the subway car somewhat because of these large spots of light on him, which look like windows.”

Ken Bryan built three CG Jeff models as a means of achieving a sense of depth and mass in the character. “The exterior skin gave Jeff his silhouette,” explained Bryan, “and told us what he looked like on the outside. A secondary interior skin mimicked the shape of the outside skin, and encased a digestive tract and some organs that you could see inside — otherwise, he’d just be an empty tube of a worm. We built these multiple layers of geometry that could be lit separately, to create the feeling that you are seeing deep down inside this jiggly, thick-bodied worm.” Creature developer Michelle Dean was primarily responsible for Jeff’s exterior look, using flesh simulations and shaders originally devised for *Attack of the Clones*.

The giant worm’s movement and style of locomotion were among the first creature issues addressed by Tom Bertino’s animation team. One of the challenges of the character’s animation was that Sonnenfeld had stated emphatically he did not want Jeff to move like an inchworm, in arcing segments. “Barry had said, ‘Don’t make him look like a roll of Necco wafers,’” said Bertino. “So I came up with the solution of Jeff propelling himself forward with his shoulders, sort of like a sea lion.”

When Jeff dives underground, Jay jumps on his back for a wild ride through the subway tunnels. On one of Sony’s largest soundstages, production shot bluescreen elements of Will Smith on a gimbal platform built by physical effects supervisor Scott Fisher. The gimbal, covered in blue and replaced with the CG worm in final shots, was motion controlled and could execute fifteen degrees of motion on any axis. “We used the platform any number of ways to create Will’s action as he rides Jeff,” noted John Berton. “Will was also on cables so he could be thrown into the air.” The gimbal action was sometimes generated by the programmable motion rig; but at other times, the crew went for a low-tech method, simply grabbing attached bars and moving the rig manually. “If we wanted a nice rolling motion, like Jeff was just cruising down the tunnel, we’d do the programmable stuff because it created a consistent rhythm that Will could respond to. If we wanted a more violent action, we just cued the grips and did it manually.”

Both the CG worm and the bluescreen elements would be composited into live-action footage shot in the real subway tunnels of New York. “There was a lot of discussion as to how to get these backgrounds for the Jeff subway sequence,” recalled Ned Gorman, “and we did our best to convince Barry that going with live footage was a good idea. For one thing, by using real tunnels, that was that much we didn’t have to build. Another advantage was that nothing beats reality. And finally, we were on an incredibly tight schedule and wanted to crank the Jeff the Worm sequence out fast — and by having real plates, we could edit the sequence with animatics using those plates, and quickly figure out exactly what we needed for our CG worm.”

"If nothing else," added Berton, "the real subway tunnels were the best place to start — even if we wound up having to build miniatures or do computer graphics tunnels, we would always know what we had to match. It gave us a baseline for understanding what our effects work needed to be."

Michael Owens filmed the tunnel plates, basing his work on crude production animatics. Both Owens and members of his crew attended 'track school' beforehand, learning how to avoid the dangers of the subway system, such as the lethal 'third rail.' "They spent two weeks working in disused or little-used tunnels in the Bronx," said Gorman, "under really horrible conditions, trying to prognosticate all the angles and speeds we would need later on. The fact that Michael and his crew got everything covered in the amount of time they did is an incredible testament to them."

Once ILM compositors began assembling the tunnel sequence, Sonnenfeld determined that the live footage — while realistic — was not sufficiently dramatic. "Barry only liked about fifty frames of the live footage," stated compositing supervisor Greg Maloney. "The problem was that when you go through a subway in New York, most of it is closed up — it's a tunnel! But Barry didn't like that closed-up feeling, with concrete walls on each side. He wanted to see more depth. So we took those fifty frames, cycled them and did some tricks with them." By flopping and stitching together the live elements, the compositors began to produce more acceptable backgrounds. Depth was suggested with three planes — Jeff and Jay comprising the middle plane, and computer generated pillars and lights comprising the outer two, positioned to flash past camera at different rates to create a parallax effect.

While the massaged live plates served most of the subway shots, a few required all-digital tunnels, built from scratch by CG artists Natasha Devaud and Peg Hunter. "Barry wanted some specific camera moves," explained Amelia Chenoweth, "which could only be done by building CG tunnels. Natasha and Peg built them under the gun, under a very tight schedule."

Jay's wild ride ends when Jeff catches up to a hurtling subway car and bucks the MIB agent through the back door of the train. Then, still



Looking for a practical approach to depict the two-headed alien onscreen, Sonnenfeld first engaged Baker and his team to build the smaller Charlie head as a puppet that could be attached to Johnny Knoxville and operated from off-camera. Though quite lifelike, the puppet lacked verisimilitude in side-by-side interaction with the real actor, and was thus utilized only for reference purposes. Leadpuppeteer Tony Urbano operates the Charlie head on set.



enraged, the huge worm begins chomping on the train itself, swallowing car after car, right up to the engine where Jay faces him down one final time. The multilayered nature of the CG Jeff model complicated shots of the worm swallowing the subway cars and, later in the movie, Serleena's ship. Ken Bryan went through such shots frame by frame, sculpting both the interior and the exterior geometries to essentially 'shrink-wrap' Jeff around the model of whatever he had swallowed. "For example, I would have a model of Serleena's ship that I could shove in there," explained Bryan, "and then I could see where the edges of the ship were poking out through the worm. I'd use that as a guide, to show me how to sculpt his interior gullet, his intestines and his different layers of flesh. He had to look like he actually contained the objects he was swallowing."

Sonnenfeld ultimately achieved the Scrad and Charlie scenes by shooting Knoxville as the human-sized Scrad on set, interacting with other players, then staging and filming his concurrent performance as Charlie against bluescreen. In post, ILM shrank that bluescreen element, isolated the head and tracked it to a digital sleeve that was animated to extend, bobbing and weaving, from Scrad's ever-present backpack.

To create the physical interaction of Jeff's biting down on the subway cars, the physical effects crew provided a practical rig. "Every time you see Jeff biting a subway car," explained John Berton, "that was a real car being crushed by a physical effects rig. We did some paint and other enhancements, but the fundamental part of that was live-action photography." Scott Fisher's crew built the subway car from real parts, then surrounded it with a rig that could 'bite down,' simulating Jeff's crunching. The rig was shot in front of the large bluescreen at Sony, with cameras placed both inside and outside the subway car to capture the metal-on-metal action. ILM then executed digital enhancement and paint work to remove the rig and attendant cables. Compositor Jason Dowdeswell added multiple layers of dust, smoke and breaking glass to tie the shot together.

Heavily armed, Jay convinces Jeff to back off. With the worm safely out of the way — at least for the moment — Jay neuralyzes his erstwhile partner while Serleena pays a visit to her number-one henchman: a two-headed alien named Scrad and Charlie. Johnny Knoxville played both Scrad — a perfectly normal-looking human — and Charlie, a second, smaller version of Scrad's head that pops out of Scrad's ever-present backpack, bobbing and weaving on the end of a long, flexible neck.

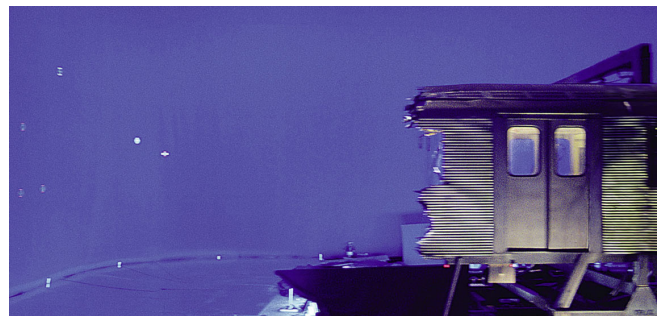
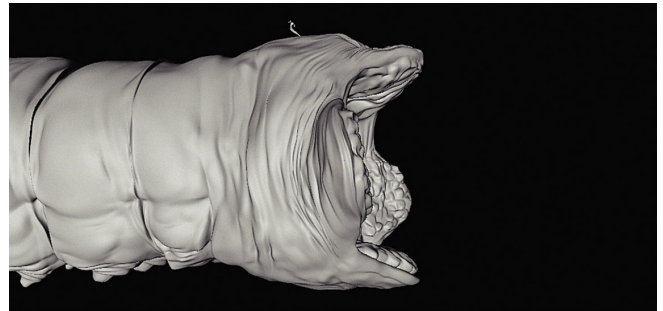
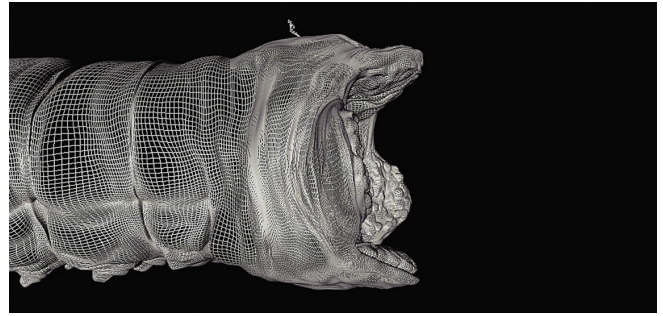
The design for Scrad and Charlie, derived directly from Barry Fanaro's original script, changed very little from the earliest days of character development; but the process of deciding on an approach for the two-headed effect — practical or digital — was a lengthy one. "From the beginning," Rick Baker commented, "I thought it should be Johnny Knoxville's head composited onto a CG neck. I told Barry that we could make a puppet that looked really good; but when it was acting next to the real head, it would have to be Johnny."

Before exploring CG options, Sonnenfeld insisted they begin with the puppet. Cinovation produced a variety of Photoshop images of the duo, and from those, Sonnenfeld determined the final size of Charlie relative to Scrad. Gentle Giant Studios then cyberscanned Johnny Knoxville and created, from that, a wax replica of his head at the small Charlie size. Cinovation project supervisor Kazuhiro Tsuji took the model and sculpted a highly-detailed bust of Charlie,

subsequently translated into a puppet head that was mounted on a four-foot-long, equally detailed neck. Mark Setrakian rigged the puppet with mechanics to facilitate movement of the jaw and eyes.

A series of video tests with the real Knoxville and the puppet head confirmed Baker's initial concerns — the puppet's limitations were too evident when compared, side by side, to the real actor. At that point, everyone — including Sonnenfeld — agreed that the effect would have to be achieved by shooting Knoxville performing as Charlie and Scrad, independently, in front of a bluescreen, then compositing those bluescreen elements into live-action backgrounds, tracking the smaller Charlie head onto a CG neck. For reference purposes only, Sonnenfeld called upon Cinovation to produce appropriately-scaled heads for both Charlie and Scrad. The smaller one was derived from the cyberscan data; the larger one was created by Mitch DeVane, who free-sculpted the head out of wet clay, then fabricated it in silicone.

Knoxville first played Scrad in the live-action plate, working off the appropriately-scaled rod puppet head of Charlie, operated by Tim Blaney, who also performed Charlie's lines during the shoot. Then, in a round of bluescreen shooting, Knoxville portrayed Charlie, this time relying on the Scrad puppet head for eyeline and performance reference. That bluescreen element was then composited into the live plate at ILM. "It was fraught with peril," said John Berton, "because it was a situation where we were trying to work something that was two-dimensional into a three-dimensional world. Johnny's bluescreen performance was just a picture, a 2D image. You can't take somebody who is facing you and make his head turn to the left in a composite and have all the light work right when it's just a 2D image. So we tried to plan out everything very carefully in shooting the bluescreen, making sure that each scene was photographed in a way that would make it successful later. It was painful, but it was worth



Agent Jay is reintroduced early in the film when he tangles with a six-hundred-foot alien worm living beneath the New York City streets. Shots of the worm — named Jeff — chasing and devouring a subway train, car by car, blended an ILM multi-layered CG worm model with a full-size, self-crunching subway car rig, built by physical effects supervisor Scott Fisher and filmed on a bluescreen stage. Artists at ILM digitally removed the rig and attendant cables.

it, because it meant getting Johnny Knoxville's performance for both Scrad and Charlie; and I think that decision paid off handsomely."

Computer graphics supervisor Mike Bauer, lead CG artist Ken Nielsen and animator Julija Learie worked together to achieve the realistic flexing of skin and other details that would sell the illusion of Charlie and Scrad occupying the same space at the same time. One of the techniques that was crucial to the success of the effect was 'match-amation.' "Match-amation is the process of match-animating a live-action 2D character with a 3D wire-frame model," said lead 3D matchmover Alia Agha. "We used a multiple camera technique in Zeno, our new matchmoving tool, that allowed us to do bluescreen extractions and precomps for the Scrad and Charlie sequence. We had to match Scrad and Charlie on separate plates, taking Charlie and precomping him with this 2½D process to the Scrad plate, shrinking his head down and placing him over Scrad's shoulder. We would then turn this precomp over to Barry for approval. He'd say, 'No, his head is too big,' or 'Move the head to the right,' and we could go back in and make changes very easily."

Connecting the two separately-shot characters was the computer generated 3D neck on which the Charlie head sat. Early on, the filmmakers had considered making the CG neck fleshy in appearance, and the ILM team took steps in that direction. "But the flesh just didn't look right," remarked lead digital paint and roto artist Katie Baird. "It looked kind of rubbery. So they decided they wanted to use Johnny Knoxville's real neck, instead of a CG neck."

Roto paint artists extended Knoxville's neck by cloning from the original bluescreen element, painstakingly matching his five-o'clock shadow, veins and skin tones. Once the neck was extended, articulate mattes were created to fit it into a CG collar — a long sleeve of cloth made to look as if it had been sewn from the same material as Scrad's shirt, a piece of which production sent to ILM. "We tried sculpting the collar by hand from that example," recalled Ken Bryan, "but we couldn't get it to look as random as the fabric; so we had it scanned. Then the creature development group took that model and applied collision bodies for the neck, so the collar could twist and slide around on the neck model like it was supposed to. That way, we didn't have to go in and sculpt every kink in the fabric."

The performance of the collar — which moved quite dynamically throughout the Scrad/Charlie sequences — was implemented by the animators. "Trying to get a performance out of that collar was very difficult," said Tom Bertino. "There was a lot of control at the base, and a lot of control at the neck of the little head at the top — but in between, the chain of the collar got temperamental and wanted to do things on its own."

Ultimately, it fell to the rotoscope, compositing and matchmove crews to make the collar gag work. Roto was given a bluescreen element of Johnny Knoxville in a very high collar with targets on it. "We had to rebuild that, painting his neck down to make a longer neck, then cutting it to fit into the small little collar."

“If the Charlie character had a neck that was the size of a normal neck, at least in relationship to the size of his head, things would have gone really smoothly,” added Mike Bauer. “But the character had an extra-thin neck, which didn’t correlate with the bluescreen neck or the neck of the actual actor. So we had the head, and we had the sleeve, and because the sleeve and the neck had to be so thin, there was a lot of meticulous hand-work necessary just to get the two to fit.” Compositors Mimi Abers and Julie Ardrianson Neary tweaked the final composite to massage the fit of the small head and neck.

The movie cuts to our first look at MIB headquarters in more than five years — and a few things have changed. Crass commercialism has made its way into the organization. A strip mall is there now, complete with a Burger King, a Sprint store and a duty-free shop for ‘tourists.’ One thing that has not changed is the plethora of aliens standing in processing lines, eating and drinking, and crowding every corner.

Designs for the headquarters aliens were worked up both at Cinovation and at ILM. After drawings had met with Baker’s approval, creature design principals would meet at Cinovation, where renderings were put up on a wall for review by Sonnenfeld. As shooting got underway, drawings and maquettes were taken to the set for the director’s approval — a sometimes slapdash process that took place in a few seconds between setups. “We usually only had about ten minutes during Barry’s lunch to show him this stuff,” recalled Cinovation production supervisor Bill Sturgeon. “So if we showed him a drawing and he said, ‘I don’t hate that,’ we would take that as enough encouragement to make a maquette. Then the next time, we’d bring the maquette in, and I’d ask him, ‘Approved?’ — and if he didn’t say anything back, I would say, ‘Okay, approved,’ and that was it.”



At MIB headquarters, scores of arriving and departing aliens await processing. Rick Baker and his team designed most of the principal and background aliens for the film. Among them were two ‘bird people’ aliens. Cinovation artists translated designs Baker had devised years earlier into the final appliance makeups, which featured beaks and feather wigs, engaging bird specialist Jeff Cruts to handle the extensive feather work.



Cinovation designer and sculptor Matt Rose attaches eye stalks to the patriarch of an alien immigrant family.

Time constraints also led Baker to take whatever shortcuts he could in producing the alien characters, including the casting of longtime friends and allies and veteran creature performers. “The whole movie was ‘Beat the Clock,’” Baker observed, “and the thing that always screws us up with makeup on actors is that they never cast the people enough ahead of time for us to do our work. So this time we suggested a lot of people we knew for the aliens — people who could deal with the makeup and had the appropriate physical attributes for the characters.”

Among the prominently featured makeup appliance aliens in the headquarters scene were Bird Guy and Bird Lady — humanoid aliens sporting bird heads, complete with beaks and bright plumage. “When I did *Grinch*,” Baker related, “I met Jeremy Howard and Mary Stein, two actors with extremely long necks. When I got involved in *Men in Black II*, I was trying to come up with something that we hadn’t seen a million times before, and I thought of a Bird People concept I’d originally come up with about thirty years ago. So I did new designs on photos of Jeremy and Mary, presented them to Barry, and Barry said, ‘Okay.’”

Kazuhiro Tsuji translated Baker’s concepts into makeups, first sculpting the Bird Guy while Mitch DeVane did the Bird Lady. “The most difficult part of putting this kind of animal design on a human face is that the proportions are so different,” Tsuji said. “It was very hard to fit everything into the planes of the actor’s face. You can go too far to try to match it, and then it becomes too thick. If it doesn’t move, the actors can’t act in it — it just becomes a mask.” Another challenge with the Bird People was creating a wig of feathers. “We’d never done that before, so we hired Jeff Cruts, the best bird-making guy in the industry. But Jeff had only made bird puppets, never wigs.” Cruts glued feathers onto a standard wig foundation. Feathers were also applied to a latex glove that covered the actors’ arms, up to the shoulder. Beaks were made detachable for the sake of the actors’ comfort, allowing them to be removed between setups without damaging other parts of the makeup.

“They had a very strong, rare-earth magnet in them to hold them on to the vacuform base — a tiny piece of it could hold ten pounds.”

All-mechanical aliens that did not have to rely on casting of performers — such as the Robot Squid, designed at ILM by Carlos Huante — were the first to be completed. The Robot Squid was the size and shape of a garbage can, with tentacles protruding from the bottom and a plastic dome on top. A pulsing, many-eyed cranium was visible inside the dome. “Matt Rose was in charge of the Robot Squid,” explained Bill Sturgeon. “He and Chad Waters sculpted most of



Cinovation project supervisor Kazuhiro Tsuji adds finishing touches to another character — one of a race of minuscule beings whose entire world is contained in a locker at Grand Central Station. For scenes in which Jay and Kay seek clues to the whereabouts of the Light of Zartha from the tiny aliens, Sony Pictures Imageworks composited bluescreen elements of performers in makeup into a Lockertown miniature.

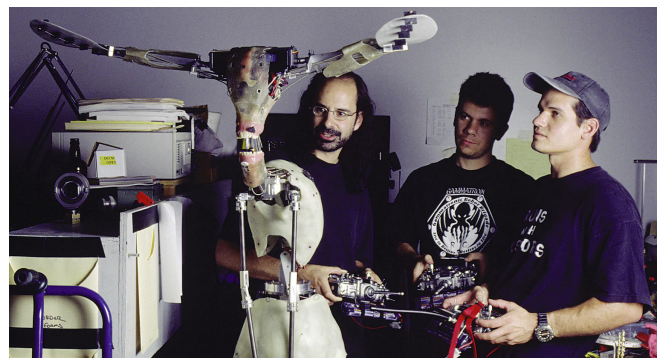
it, and Jeanne Vosloo did the fabric middle part, which housed mechanisms built by Kyle Martin and Mark Setrakian. It was, basically, a really expensive radio control car. The individual tentacles had wires in them, and there were motors attached so that as the Robot Squid moved it looked like the tentacles were moving.” Two big wheels underneath enabled the crew to move the character as needed. In addition, a parallelogram mechanism facilitated up-and-down and sideways movement. “The dome itself had four degrees of movement, the head inside the dome had four degrees of movement, and each of the eyes moved around, too.” In the final film, the Robot Squid was featured for only a few frames.

One of the first headquarters aliens to make it through the design, approval and construction processes was the Big Dead Alien, the multi-tentacled, elephant-sized mass that is dragged across the headquarters floor due to an out-of-service morgue elevator. The Big Dead Alien had actually been designed and built for a scene that was cut from the movie, in which Agent Elle (Linda Fiorentino) was going to be seen conducting an autopsy. Because of the size of the creature, the Cinovation crew, led by Bart Mixon, had started on it immediately in order to have it done in time for filming on the morgue set. “Originally,” recalled Sturgeon, “it was supposed to be flopped out to take up the entire ground space of the set — fifty feet, if you spread the tentacles all the way out. It was so big, it couldn’t fit in our shop. So we rented another shop down the street that had been the Planet of the Apes costume department, and that became the Big Alien Shop.”

Twenty-some people worked more than three months on the foam latex sculpture, and the project was nearly complete when word came down from production to stop working on the Big Alien. “For whatever reason,” Baker recalled, “we were told that Linda Fiorentino — who had been in the first film — wasn’t going to be in this one, and so the morgue scene was cut. We figured we had made this giant thing for nothing.”

Because the massive alien was essentially finished, and had already been paid for, the filmmakers decided to move it to headquarters and have it towed across the floor — a last-minute decision that caused some trouble for Bo Welch and his art department. “It was kind of a heartbreaker for Bo,” Sturgeon commented. “He had the set perfectly designed just the way it was. Even the placement of the chairs was perfect. Then he suddenly had to rip out a huge swath and figure out a mechanism that would haul this thing that was never meant to move across the floor.”

During the two days of shooting the headquarters scenes — both Jay’s first appearance and the later arrival of Kay and Jay together — more than a dozen artists were on the set to apply and maintain the alien makeups, while others from Cinovation maintained and operated the



In addition to aliens portrayed by performers in makeups and costumes, Cinovation supplied the production with a number of all-mechanical species. Mechanized aliens were often the first to be completed because - unlike the makeup-dependent characters - their construction did not rely on the prior casting of performers. Lead mechanical designer Mark Setrakian and technicians Pete Abrahamson and Kyle Martin conduct a test on the animatronic endoskeleton of a hammerhead character dubbed Flap Jack.

mechanical aliens. Throughout, the Cinovation crew continued to design and create makeups on the fly as ideas arose on the set. “There were lesser makeups that we threw together at the last minute,” stated Sturgeon. “Barry wanted a few more, and we didn’t have enough time or money to do appliances, so we would just throw something together. For example, Barry liked this contortionist that we had on set, but no one had figured out a way to put him in the scene. So they finally made this aquarium thing that he could contort into. We took a mask from the last Men in Black — one that we hadn’t used — and pulled that alien together very quickly.”

“We made all of these guys as if they were the stars of the movie,” added Rick Baker, “even though a lot of them were only set dressing. I’ve learned that if we make them as set dressing — if we don’t finish off certain parts, or we don’t bother putting a mechanism in them — the director will always want them to do things they can’t do. The only answer is to make them so they can do pretty much everything — even though most of them will end up as nothing more than a blur going past camera. This time, I was pleased to see how much stuff wound up in the finished film.”

One alien character who makes his first Men in Black II appearance in the headquarters scene that could be afforded star status was Frank the talking pug. Featured in only a single brief scene in the original movie, Frank was a serious secondary lead in Men in Black II — and a serious scene stealer. Though the character was portrayed by a real pug named Mushu, his facial performance, including dead-on lip sync, was the product of computer animation. The ILM team had originally intended to perform all of the Frank animation in-house; but as the character’s part grew, so did the animation work load. ILM turned to Rhythm & Hues, a company venerated for its animal lip-sync work since the first Babe movie, to produce 28 of Frank’s forty-some shots.

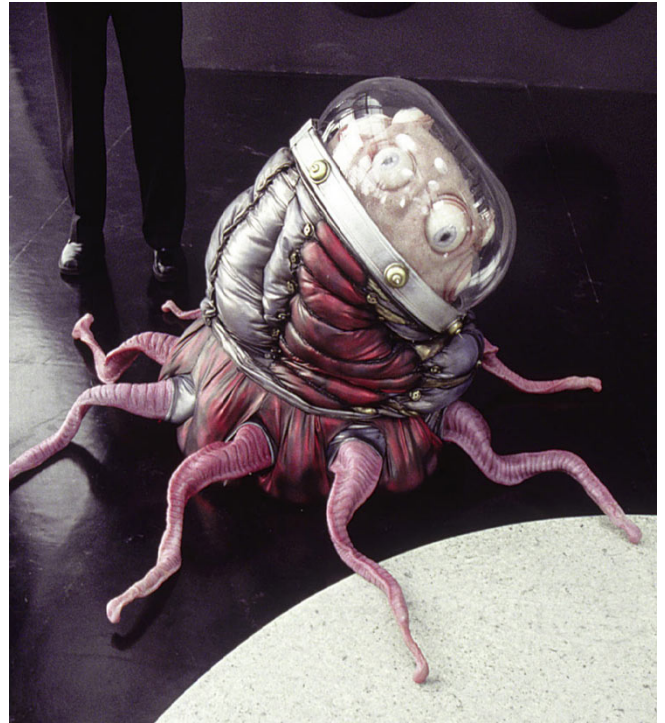


Rick Baker – in costume for his cameo as an MIB immigration officer – relaxes on the set with Barry Sonnenfeld between takes.

Though the two companies worked independently, their approaches were similar. Both replaced some or all of Frank's face with a CG version to allow for the animation of his mouth area for talking, and the animation of other facial areas for more dynamic expression. At Rhythm & Hues, where artists worked in a proprietary animation package called Voodoo, the entire face was built in CG for every shot. "We always build the whole face in CG whenever we're doing this kind of lip-sync work," explained R&H visual effects supervisor Bill Westenhofer, "so that we can replace the live-action with our face. 'Replace' is a bit misleading, though, because we don't build all the texture of the live-action face in CG. We try to use the real face projected onto the CG geometry on every frame." In those rare instances in which the live-action texture was not available for a given shot, artists created it from scratch. "We took a lot of reference photos of the dog so the texture painter would know what it should look like. But we did animate the entire face for every shot, including the brows and the eyelids. For instance, when Frank is singing in the car, he squints his eyes as he gets into the song. We would animate that sort of thing, along with the mouth and jaw movement."

Lip-syncing lines of dialogue involved laying in the CG jaw, then animating lips on top of that. "We animated the mouth movement using slider controls," said Westenhofer. "There were controls for the mouth, the upper lip, and they all had sympathetic motion for when the jaw opened. The soft tissue surrounding the jaw had to be animated, as well." The greatest animation challenge for R&H was a sequence in which Frank talks with a cigar in his mouth. "The dog was actually filmed with a fake cigar in his mouth; and although we replaced it with a CG cigar — complete with smoke coming out in puffs — that was helpful to us because it gave us reference for how he would hold it in his mouth."

ILM artists completed their twelve Frank shots similarly, with animation lead Miguel Fuertes working out lip-sync shapes in Caricature — ILM's proprietary modeling and animation program — and building up a library of phoneme shapes that could be plugged into the pug shots as needed. In a playful moment, Fuertes gave Frank an Elvis-like sneer — and Sonnenfeld loved it. "Barry said: 'Yeah, he's got a tough street attitude — he looks like a wise guy,'" recalled Tom Bertino. "'I like that. Keep up that sort of thing!' So, aside from straight articulation, we also got into a number of expressive extremes: sneers, little rolls to the lip. Each of those was modeled so that the animators could choose which they wanted to use for a specific shot. We had a library of eye and eyebrow movements, too, which we implemented using sliders."



One of the mechanical aliens briefly featured in the headquarters sequence was the Robot Squid. The character was mechanized to travel across the set floor, via radio control, and had additional mechanisms to provide tentacle and head articulation.

ILM also relied heavily on match-amation to realize their Frank shots. Normally, match-amation begins with a cyberscan of the subject's head, which is used to produce a wire-frame onto which live-action footage can be projected. Capturing a wire-frame of the pug's head was not a simple matter, however. "We had a cyberscan of Frank," Alia Agha recalled, "but since you can't keep a dog still during the scanning process, the wire-frame we got from that was marred with all kinds of grunge. We were able to use some of it, but we still had to completely rebuild the model." Location matchmove artist Randy Jonsson took 360-degree photographs of Frank's face, which were provided to Ken Bryan and creature supervisor Tim McLaughlin. "They built the pug model from those photographs, and matched it to the real plates so they could see how his forehead or cheeks or jowls fit. His jowls were a big issue because as he talks, they flap — and they had to flap correctly. In some cases, we even had to rebuild his neck and chest, just to get everything to work. We really had to build a better pug."

Improved matchmoving enabled the ILM crew to precisely track the CG pug parts to the live-action. "I was a matchmover on the first *Men in Black*," Agha remarked, "and it's a very different job now than it was then because matchmoving has evolved so much. The Frank the Pug shots in the first film were tracked by hand, with a lot of pixel-splitting in Softimage, which was time-consuming. Now, with Zeno, it was a much quicker process."

Across town, Serleena interrogates Ben the Zarthan at his pizzeria in Soho — then casually splits him down the middle, releasing a burst of starry light. The split-and-explosion effect was accomplished by lifting actor Frank Kehar out of the scene by cables, then removing those cables and adding an explosion effect in postproduction. All that is left of Ben is a hollow human skin — actually a prop left over from the original *Men in Black*. "That skin was from a mold of Vincent



Jay seeks out Kay — voluntarily memory-wiped by neuralyzation at the end of the first film — in a small-town post office where the ex-agent now works. To prove the existence of aliens to his skeptical former partner, Jay 'outs' a number of non human postal workers — including one, portrayed by John Berton, whose outwardly human appearance is just an elaborate mechanical construct housing an alien operator. For a scene in which the figure splits in half to reveal its inner workings, Berton was stood in a hole in the set

D’Onofrio, Edgar Bug in the original MIB,” noted Baker. “It was just something to be dropped on the floor, and we were told it was never going to be seen after that — but, of course, it was.”

“Luckily,” added Bill Sturgeon, “Frank Kehar’s build was close enough to Vincent’s that once it was flopped on the ground, you couldn’t tell it was someone else’s skin. We punched hair into it and repainted it and gave it different eyes, so it actually kind of looked like Frank Kehar. We took his clothes and put a thin foam inside them to thicken them. Then we used a lot of super-glue to position it on the ground so that it looked right for the camera.”

The crime scene at the pizzeria introduces Jay to the mystery surrounding the Light of Zarthia, and leads him to retrieve the neuralyzed Agent Kay from his postal job in small-town Massachusetts. Jay’s explanations regarding Kay’s past and the Men in Black fail to convince the former agent, until each of the workers in the post office — all of whom look like almost-normal human specimens — removes a part of his body and reveals himself to be Not of This Earth.

Sonnenfeld had a very specific look in mind for the human versions of the ‘postal aliens.’ “Barry said to us: ‘If you walked down the street in New York, you’d see the kind of guys I’m looking for,’” recalled Bill Sturgeon. “‘There are guys that look like they’re from another planet — and that’s what I want.’ It was a real fine line to walk. They had to look weird, but not too weird. He didn’t want them to look injured or as if they were some kind of mistake — he just wanted them to look a little bit off.”

For the revealed aliens themselves, Rick Baker and his team created dozens of concepts, ultimately boiled down to four: Eye Guy, Split Guy, Joe and the Sorting Alien. Matt Rose sculpted a five-inch-tall maquette for Eye Guy, whose head is a large blinking eye. “We did an AfterEffects image,” said Sturgeon, “where we took a shot of me, cut my head off, and had this little eye coming out of my neck, going ‘blink, blink.’ The blinking is what made the joke work.” Bud McGrew mechanized the character so that he could shrug little

floor, adjacent to a leg-and-torso animatronic built by Cinovation.



Back at MIB headquarters, Kay innocently probes a glowing ball with his finger, inadvertently causing a massive tidal wave to surge over the tiny alien city of Jaritha 5, contained within. Though a short, essentially throwaway scene, the all-digital segment was in production for eight months as Sonnenfeld and ILM artists refined Jarithian performances and the overall look of the environment.

arms and do a number of other moves — although, in the final film, Eye Guy is seen only blinking.

Split Guy is first seen as a tall, blond fellow with a pony tail; and next appears in two pieces, with his top half sitting flat on the floor and his bottom half under the control of a globby three-eyed alien who had previously been hiding inside the torso. Split Guy was accomplished by placing a person in a hole in the set, making him appear to be flush to the floor, and lining him up to a Baker animatronic on top. That person was none other than John Berton, who epitomized the ‘New York street person’ look Sonnenfeld wanted in the post office humans. “It was funny,” Rick Baker recalled. “I was saying, ‘We have to cast interesting-looking people, people who have a lot of character in their faces — and there’s one right there!’ I pointed at John, who has a great face, and we used him in that sequence.”

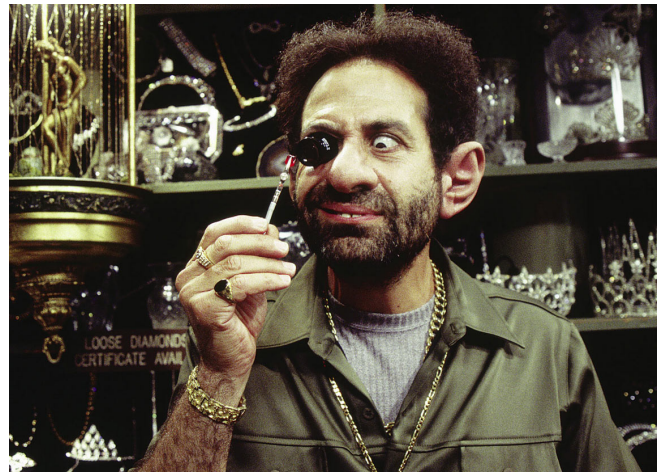
‘Joe’ was a long-haired, large-featured character who pulled off his hair — and half his head with it. “We did a makeup on Doug Jones,” said Sturgeon, “whom we’ve worked with before and has a very cool-looking body. We did a little bit of work on him to accentuate his lips and eyes and hair, so that when he pulled the hair off, he had no hair and teeny little eyes.” The effect was accomplished entirely in camera with a large appliance on Jones’ face and a pair of one-of-a-kind sunglasses that the prop department borrowed from makeup artist Chet Zar. The revealed head was a mechanical model. “It was Doug Jones in makeup for all the shots leading up to the reveal. Then, when he takes his head off, we cut to a mechanical puppet that had a skull-piece wearing the same glasses and wig — a piece that cut away just above the glasses. Doug stood directly behind the puppet and reached up to peel the skull piece back, revealing the mouth-head mechanical.”

The last of the post office aliens, the Sorting Alien, combined practical effects with CG effects provided by Tippett Studio. In the sequence, Jay opens up a large letter-sorting machine, revealing to Kay the eight-armed alien inside. “This alien is in a cubicle office,” explained Tippett visual effects supervisor Scott Souter, “smoking and drinking coffee and sorting mail, all at the same time.” Actor Jeremy Howard was in a wall-eyed makeup devised by Kazuhiro Tsuji and based on a design that originated at ILM. During filming, Howard also wore bluescreen material on his real arms, inside oversized sleeves. “He was wearing the short-sleeved shirt worn by postal workers, but the costume people made each sleeve large enough for four arms to fit through. They even attached some air hoses onto the sleeves, so when he was supposed to be sorting mail, the air would whip the sleeves around. Once we got the shots, we painted out all the air hoses, got rid of the blue arms and put in eight alien arms that were thinner than human. They had three fingers and a thumb — skinny arms with bulbous joints.”

Activity and imagery behind the blue arms had to be reinstated by the Tippett rotoscoping group once the bluescreen appendages had been removed. “One of the more challenging things,” recalled Tippett visual effects supervisor Jim McVay, “was a man who was walking in the background behind one of the arms. The roto team had to create most of that man’s legs as he was walking by — and they did a seamless job of it.” Much of the cubicle environment also had to be constructed in CG so that appropriate shadows from the arms and flying mail could be cast.

To provide a bit of set dressing before the reveal of the Sorting Alien, the Tippett team animated hundreds of CG letters flying from the machine and filling rows of CG cubbyholes that matched those on the set. “We needed some place for the letters to go,” explained McVay, “and so we needed CG cubbyholes. Since we had cubbyholes in the photographic plate, we didn’t have to render them — we just needed the CG geometry to give the CG letters a place to go. The letters were occluded in CG-land by our CG cubbyholes, so they would appear as though they were sliding into those on-set slots.” The letters themselves were based on those in the live-action plate. “We created five different styles of letters — enough variation so that it didn’t look as if the same letter was being thrown over and over again.”

Now convinced of the existence of the alien underworld and his former role in policing it, Kay returns with Jay to MIB headquarters. There, the curious Kay dips his finger into a small glowing ball, causing a tidal wave to surge over the city of Jaritha 5 inside it, sending tiny alien inhabitants running for their lives. Ironically, the short, essentially throwaway digital scene was in production at ILM for a very long time. “It was on the table when I came on the show in September 2001,” noted Tom Bertino, “and we didn’t get a lock on it until April 2002. Aside from visual effects issues, such as the tidal wave and the overall atmosphere, there were the issues of the alien characters and their performances. Barry didn’t want the Jarithians to be cartoony, so he kept toning them down and getting their performances as grounded in reality as possible. Barry would say: ‘This isn’t for the camera — don’t play them that way. If you’re really running for your life, what are you gonna do?’ He wanted the wacky to come entirely from context.”

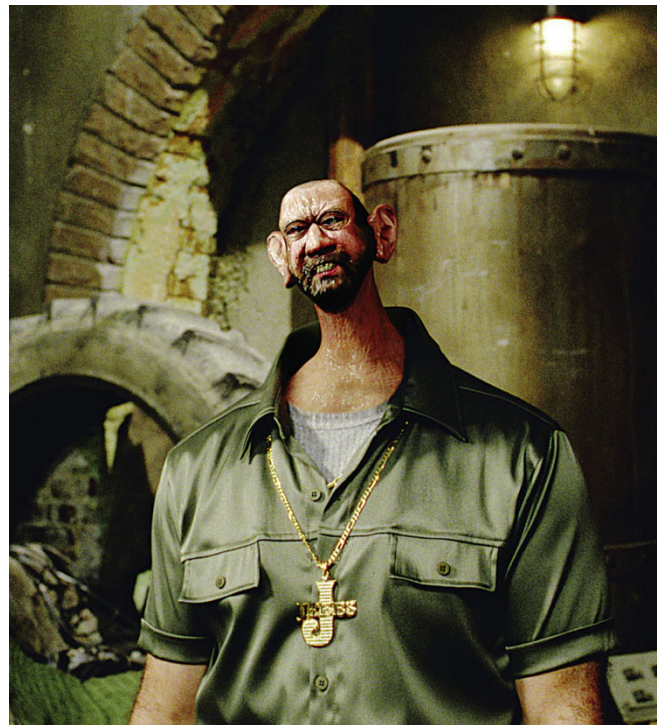


With MIB headquarters occupied by Serleena, Jay and Kay cannot access the deneuralyzer needed to restore Kay’s memory and return him to duty. Seeking an alternative, they pay a visit to alien pawnbroker Jeebs (Tony Shalhoub), whom they suspect has a jury-rigged version of the device in his basement. To suggest that the shape-regenerating Jeebs has had his head blown off a few times too many, Cinovation created gelatin prosthetic pieces that distorted the character’s features even more dramatically than in the first film.

As Kay and Jay head off to the MIB deneuralyzer, Serleena arrives and takes over the headquarters, filling the space with her eel-like tentacles. Sonnenfeld dubbed the effect of the tentacles emerging from Serleena's fingertips, seen throughout the film, 'finger cheese.' The finger cheese takeover of the MIB headquarters was realized in only six digitally enhanced shots. "Six shots isn't a lot," noted Erik Mattson, "but they were very complex. Four or five of them are fairly quick cuts — thirty to fifty frames — and then there's one long shot. We used a combination of motion-captured digital doubles and 2D manipulations of existing live-action agents, where we picked them up and moved them around. We didn't have to scan the actors for the digital doubles — we had photographs of their faces and rough measurements of their bodies, and because they were all wearing essentially the same costume, we were able to cut down on the number of different textures we had to generate by copying one to the other. We hoped to get away with that, and we did."

Serleena's invasion triggers a 'Code 101' lockdown of headquarters; and the deneuralyzer room — a sterile white environment with curved walls — becomes essentially a giant toilet bowl, complete with Ty-D-Bol blue water, that flushes Jay and Kay right out of the building. Only a few gallons of dyed-blue water were introduced into the real set; most of the live flushing action was shot in a water tank elsewhere on the Sony lot, with a number of pontoon-mounted cameras capturing Jones and Smith as they swam in the swirling water. A following shot of Jay and Kay rushing headlong through the transparent pipes beneath MIB headquarters was entirely CG. The trip ends with the agents being released through two 'nitrogen tanks,' actual city artifacts mounted on the sidewalk at Broadway and 42nd Street.

Back on the streets, Jay and Kay hurry to the basement of the alien Jeebs (Tony Shalhoub), where they believe a bootleg version of the deneuralyzer has been put together from blueprints on the Internet. A featured character in the first film, the head-regenerating Jeebs looks as if



Jeebs suffers yet another shot to the head when Jay fires on him with a blaster borrowed from the MIB armory. As in the first film, the disintegration of Jeebs' head proves no more than a minor annoyance to its owner, and the alien quickly restores himself — more or less — to his former state. ILM computer generated the explosive head-splatter, as well as the subsequent regeneration of the alien's head.

the previous five years have been tough on him. “Each time Jeebs gets his head blown off,” said Bill Sturgeon, “he comes back a little less symmetrical. And the idea here was that he’d had it blown off a couple of times since the last movie. If you look closely, you see that one ear is normal, but the other is very big; and the eye that was a little off before is way off now.” The Jeebs makeup consisted of a gelatin nose and chin, and the bigger and smaller ears. “He also had a contact lens that matched his good eye, so we could place it slightly off-center.”

Kay’s deneuralyzation is barely complete when he and Jay are attacked by five of Serleena’s interplanetary thugs, designated by their creators as Cornface, Third Eye Guy, Dog Poop, Tendril and Flesh Balls — all initially human-looking characters who reveal their alien characteristics in the height of battle. Cornface removed his human mask to show his true disgusting features; Third Eye Guy took off a cap to reveal an extra eye in his forehead; and Flesh Balls dropped his turtleneck to display a scrotum-like lower face.

Both Cornface and Tendril were straightforward appliance makeups, while Third Eye Guy required a bit more work. A makeup consisting of a skullcap covering a third eye was designed for Kevin Grevioux, a favorite Baker performer who had appeared as numerous characters in Planet of the Apes. A small mechanism built into the actor’s skullcap made the eye blink — though the effect is not seen in the final film.

The most challenging character in the basement sequence, at least in terms of concept, was Flesh Balls, referred to as a ‘Ballchinian’ in the film. “The issue was how far to go with that,” stated Bill Sturgeon. “Rick’s idea was to put him in some type of high collar, so we wouldn’t actually see the joke until the lower half of his face was revealed.” The makeup consisted of a complex appliance driven by servos. “The character’s mouth is up high and very small,” observed Kazuhiro Tsuji, who created the makeup based on Baker’s design. “It’s really out of proportion. So we made little teeth inside a little mouth, and mechanized the mouth with three servos. Even the balls on the alien’s chin had servos, so they could swing back and forth when he spoke.” To enable the actor to



Alien thugs, designed by Rick Baker and realized by Cinovation, confront Jay and Kay in Jeebs’ basement. Makeup for one of them consisted of a skullcap into which a synthetic third eye was mounted, mechanized to blink – although the blinking action never appears in the film.



Another thug– aptly named Dog Poop by the crew – required a head piece and multiple facial

remove the appliance throughout the long shooting day, the false mouth and chin were attached to the actor's face by screws on either side of the mouth, the seam hidden in a deep wrinkle.

appliances. Project supervisor Bart Mixon attends to the application.

With the thugs dispatched and Kay's memory mostly restored, the agents seek the help of the Worm Guys to rescue MIB from Serleena's snaky clutches and protect Laura. Briefly-seen generic characters in the first *Men in Black*, the Worm Guys were promoted to supporting roles as MIB accountants with names and personalities of their own in *Men in Black II*. During the early, time-crunched stages of design on the first movie, Baker had conceived the characters as something that could be built as rod puppets, without having to wait for the casting of performers. Initially shelved, the Worm Guys became the rookie Jay's introduction to the alien world in the MIB break room — and among the film's most popular characters.

Their popularity, in fact, guaranteed their inclusion in the sequel — but when Baker saw the new script, he understood immediately that the Worm Guys would have to be redeveloped from scratch. "They were designed and sculpted by Aaron Sims for the last movie as almost a throwaway thing," recalled Bill Sturgeon. "We found the original one-piece mold and did a master, and then resculpted it because it wasn't at all suitable for what the Worm Guys had to do in this movie. We made specific molds for the arms and other body parts, rather than do it as one mold, which is hard to mechanize."

In *Men in Black II*, the Worm Guys — Sleeble, Gleeble, Neeble and Mannix — are introduced in their mod bachelor apartment. Cinovation built ten puppets for the apartment scene, the set for which was erected ten feet off the ground to allow for puppeteering. The puppets were mechanized to perform a number of movements, some of which were achieved by rods attached to various anchor points. Two or three puppeteers worked in concert to create the performance of any one Worm Guy. "Usually," explained Sturgeon, "one puppeteer had a joystick that controlled the neck and a little pistol-grip for the mouth. Then there was a person producing the gross body movement with a stick that came down through the torso. And sometimes, just before the shot, Barry would say, 'I want the hand to do this,' so they'd attach monofilament to a hand or wrist to get that action. It was all done on the fly." Puppeteer Tony Urbano served as overall puppeteering supervisor.

CG worms were interwoven with the practical versions; and like Cinovation, ILM incorporated subtle changes in the individual characters. "The paint job was changed just a little bit,"



An alien dubbed Cornface — another makeup creation — lifts Jay and bends him backward, nearly snapping his spine, during the basement fight. The seemingly contortionistic maneuver was accomplished by hanging Will Smith upside down from a rig so that the upper half of his body draped into the frame, while his double, hanging upright just next to him, supplied the rest of Jay's body from the waist down.

recalled Ken Bryan, “and this time they all had clothing and costumes and weapons, whereas previously, we just saw them naked. Several modelers worked on building these new costumes for them.”

Derrick Carlin served as animation lead on the Worm Guys, and based their animation on personality profiles provided by the production. “Barry goes very deeply into the characters and personalities of all these creatures,” noted Tom Bertino, “and we were provided with a sheet of traits that each character had. Mannix, for example, is this blustering tough guy who pictures himself as Rambo and sees himself as the leader. Barry even made distinctions about whether a character came from Brooklyn or Jersey, and he delivered that to us as important character background. That kind of detail was never spelled out on the screen, but it gave the puppeteers and the animators vital information as to why a character carries himself a certain way, or why he moves the way he does.”

Once Laura is safely hidden with the Worm Guys, Jay and Kay follow Kay’s own clues in the city to uncover the truth about the Light of Zartha. The quest leads them to a locker at Grand Central Station that houses the strange little world of Lockertown. There, Kay is worshipped as the Lockertown inhabitants’ god, a watch is the town square clock, and instructions on a video-store card are as revered as the tablets given to Moses on Mount Sinai.

Lockertown’s alien citizens were designed by Rick Baker, and realized by performers in makeups and suits. “Since they’re in this little locker,” Baker explained, “I felt they must be packrat characters. Their whole village is made out of trash they’ve scavenged off the floor at Grand Central Station. I felt they should be very rodent-like, but still appealing — mammals with hair. So I did these Photoshop renderings that were kind of meerkat-like — big eyes, antennae to make them a little more odd. I did the designs, then Eddie Yang built suits for the performers.”

The Lockertown aliens — including their leader, Moses, played by the film’s stunt coordinator, Charlie Croughwell — were shot bluescreen. That bluescreen footage was then composited with a Lockertown miniature built by the Sony prop department and shot motion control to match camera moves on the bluescreen stage.

Sony Pictures Imageworks assembled the sequence, with senior visual effects supervisor Ken Ralston and visual effects supervisor Sheena Duggal overseeing the assignment. To give themselves as much flexibility as possible, Imageworks artists had the Lockertown miniature — which had already been shot by production — delivered to their stages so they could shoot additional digital stills. “We did a fair amount of matte painting work to enhance the existing footage of the miniature elements, too,” stated Duggal. The Imageworks crew broadened its choices by shooting supplemental bluescreen footage when Baker’s makeups and costumes were in use for the filming of Will Smith’s *Men in Black II* music video. “Our CG supervisor, Daniel Eaton, ran out to shoot some extra plates during the making of the music video, which gave us a little more flexibility in the composition of these shots and, more importantly, enabled us to fulfill Barry’s creative vision. It was real guerrilla filmmaking.”

Besides the extra footage of the Lockertown citizens — which Imageworks dubbed ‘furbies’ — the company also created digital versions to fill out the backgrounds. For large groups of

furbies, Imageworks utilized its own crowd simulation software, first employed on Harry Potter and the Sorcerer's Stone and Spider-Man. "We adapted our existing technology, which uses motion capture and particle systems," Duggal explained, "and made different action cycles to control the motion of the CG furbie characters." An elder furbie walking down a hill, seen from a high angle, was also a CG character. To make the Lockertown environment in the shot, Imageworks filmed a plate of the miniature and used it to do a matte painting. "That gave us the ability to control the depth of field." Imageworks assembled the entire Lockertown sequence in only four weeks.

Kay and Jay return to the Worm Guys' pad, only to find that the aliens have been cut to pieces by Serleena and Laura has been captured and taken to MIB headquarters. The worms regenerate themselves — a straightforward CG effect by ILM — then join the MIB operatives in a final assault on the headquarters, where two new formidable threats await them: the gatbot and an alien named Jarra.

The gatbot — an innocuous-looking domed canister that changes, transformer-style, into a killer multi-gun robot — was a digital effect that arose late in production. "We got a little script note while they were shooting in New York," recalled David Nakabayashi, "which said they wanted us to come up with concepts for a robot that changed from a lipstick canister to a killer robot. We knew it was going to start as a lipstick-type container, so we used lipsticks as a point of reference. But when we looked at the shape and proportion of a lipstick, we knew it wasn't going to work. A lipstick container is cute and everything; but when you blow it up to a larger size, it looks like a trash can. Barry finally said, 'Okay, then it is a trash can — a Men in Black trash can.' It evolved from there."

Paul Theren modeled the gatbot, and included in the digital construct all the robot's unfolding mechanisms and weapons. "It was a heavy model," said Ken Bryan, "because there was so much detail that had to go into the little guns. Each barrel had to be able to rotate — and it had many barrels. Just to make one gun pop out would have been complicated enough; but there were guns popping out all around the gatbot. Building all of that stuff so that it would work like a real object was not an easy job." A physical mockup of the gatbot in its closed, trash-can configuration was built for live-action filming, and appears as the robot first approaches the MIB elevator. The film cuts to the CG version as the robot transforms and begins spraying the elevator with hot lead.

Jay then goes head to head with Jarra (John Alexander), an extremely tall master criminal who appears to be harmless enough as he floats



A bit character in the original film, Frank the talking pug took on a major supporting role in the sequel. As before, lip-syncing was achieved by replacing part or all of the real pug's face with a digital construct, animated for speech and expression. The forty-some talking-dog shots were divided between ILM and Rhythm & Hues. Among those produced by Rhythm & Hues were shots showing the hard-boiled pug chomping on a cigar — digitally extracting a fake cigar clenched in the

through the occupied MIB headquarters. It is only when Jarra is confronted by Jay that he opens his floor-length cloak to reveal that he is riding in a small flying saucer, and that he is host to a horde of other, smaller Jarras, each in its own armed saucer.

The Jarra concept evolved from the specific abilities and talents of Alexander, a veteran suit performer who had played the role of the gorilla Digit in *Gorillas in the Mist*. Knowing that Alexander came from a circus background, Cinovation artist Matt Rose had conceived the idea of the actor riding on a unicycle beneath his long, bell-shaped cloak, making him appear to float through the headquarters environment. "It would look as if he had this big body and very small head," Baker related. "But then, when the cloak came off, you would see that it was just the opposite — his head was big and his body had withered away, and was in this little flying saucer. We pitched the gag to Barry, and he loved it. In fact, he made it a much bigger part — it was Barry's idea to have all the little Jarras underneath the coat."

The Jarra reveal and subsequent battle with Jay — 46 shots, total — were accomplished by tracking bluescreen elements of Alexander's head to digital models of his withered body and saucer, built by Paul Theren. Once both the creature and hard-surface aspects of the model were developed, they were applied to the smaller Jarras, dubbed the 'Jarrettes.'

The skin texture on all the Jarras, big and small, was accomplished through one of ILM's in-house shaders, enhanced considerably by Jean-Claude Langer and Catherine Craig of the 3D paint department. "Our 3D paint department really made it work," sequence supervisor Will Anielewicz commented. "They put in a huge level of detail, with many organic surface qualities. That department is the reason creatures coming out of ILM look as good as they do."

real dog's mouth and replacing it with a smoking stogie.



Other minor players in the first film promoted to key supporting roles in the second were the alien Worm Guys. Designed by Cinovation as one-piece rod puppets for their brief appearance in the original movie, the new action-oriented Worm Guys had to be rebuilt from scratch and more fully mechanized for the sequel.



Cinovation crew members prepare to film a scene in the Worm Guys' apartment set, built on a

platform ten feet off the stage floor to accommodate puppeteers underneath.

Anielewicz's informal designation as in-house reflective metal expert made him a prime candidate for overseeing the look and lighting of the Jarra's metallic saucers. "I do a lot of Mental Ray rendering techniques," said Anielewicz. "I came in on Jarra to refine the saucer, making subtle changes in everything from the color to the texture to the specularity to certain links of how the arms and hands worked."

Jarra's hair accounted for some of the most challenging work for the ILM crew, which spent many months attempting to match Alexander's hair in the bluescreen footage. Cinovation had actually tried to ease the CG hair problem by slicking back Alexander's hair in the practical makeup, and making it adhere as closely as possible to his head. Unfortunately, the grease-down worsened the situation for the CG team, because it resulted in wet, tufting strands that did not respond well to standard hair simulation processes, in which a few guide hairs are set and the computer interpolates movement for thousands more. "The average human head has about 80,000 hairs on it," observed Anielewicz, "but on Jarra, I got away with between eight and sixteen thousand because his hair was thinning. But because there were so few of them, the guide hairs had to be quite specifically laid out. I felt like a hair stylist, working with each of the little splines." In some shots, Alexander's live hair was intermixed with the CG hair, which required even more precise matching.

Lead Jarra animator Chris Armstrong and key animators Mordechai Weisbrod, Kim Thompson and Tim Waddy tackled the problems of creating a performance with a character that was part-digital, part-bluescreen. "We were limited in what we could do with his face," said Tom Bertino, "which was, for the most part, a bluescreen element of the actual actor. Fortunately, matchamation gave us a way to build a 3D face that would go on the animated model like a texture element, so we could get a little moving and turning — and we still had the performance of the actor, which freed us up a lot."

Determining that both Jarra and the Jarrettes would be locked to their respective saucers, animators treated the spacecraft as physical extensions of the characters' bodies. "We rotated them like hips," said Bertino, "so it wasn't like a ship he was piloting — this was actually part of his anatomy. We tried to make it specific, even invoking specific actions on the levers and dials in front of him for corresponding actions to the ship."

The Jarra sequence also presented ILM's roto department with a huge workload, particularly a shot in which Jay climbs the Jarrettes as if they are stairs. Will Smith had been attached to cables to secure him as he climbed a stack of boxes standing in for the little aliens. All of the



For action scenes too dynamic to be performed by the Worm Guy puppets, ILM built and animated digital versions, then composited them into live-action scenes, such as one in which the Worm Guys help Jay and Kay liberate MIB after Serleena's takeover. Digital modelers fashioned wardrobe and weapons for the worm characters, who appeared wholly unclothed in the first film.

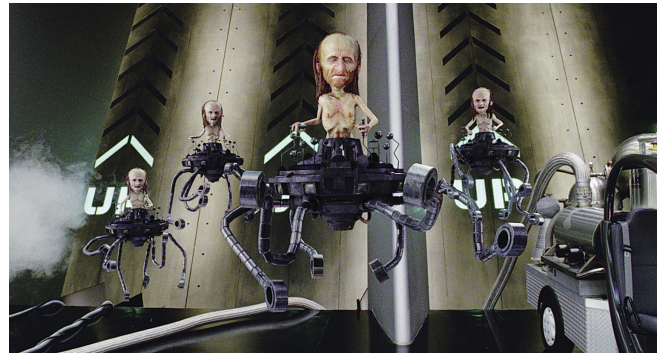
rigging, wires and boxes had to be removed from that live-action plate. Though there was a clean plate shot to facilitate rig removal, time constraints on the set had resulted in the scene's being shot without the benefit of motion control. The live-action crew had approximated the action footage in the clean plate; but in the end, it was left up to the matchmovers and compositor Tim Gibbons to rebuild the background. "The compositors rebuilt the background," said Katie Baird, "and we created articulates of Will Smith running and painted out all the wires that crossed over him. Then we noticed that the motion blur made his feet and hands look like sticks — they were just blurred out completely. So Jiri Jacknowitz had to paint parts of his arms and his legs back in."

While Jay battles the formidable Jarra and his flying clones, Kay is literally swept off his feet and held captive by Serleena's undulating tentacles. To sell the physical interaction of the CG eels with Tommy Lee Jones, the actor was wrapped up in cords that constricted him a bit and created wrinkles in his clothing. Before Serleena can crush all the life from Kay, Jay shows up, fresh from his victory over Jarra, and blasts her to smithereens. Jay, Kay and Laura rush out of the liberated headquarters, unaware that a small fragment of Serleena remains, and is already growing back to continue the chase in a spacecraft — an ILM digital construct. From there, it is a race against time to get the Light of Zarthia — which, it turns out, is Laura — to the designated departure point.

Kay and Jay's edge in that race is a flight-capable Mercedes-Benz 500e. Sequence supervisor Joel

Aron, an auto and motorcycle enthusiast who had contributed to the car scenes in the first *Men in Black*, worked closely with associate visual effects supervisor Ed Hirsh to engineer the all-digital transition between the assembly-line Mercedes-Benz and the MIB supercar, designed by Bo Welch. As the sequence was designed, the transformation had to take place in only two shots: the first with the camera facing the Mercedes head on, and the second with the camera on the backside of the car. Sonnenfeld's mandate was that the transformation, though quick, not look like a morph. Rather, Sonnenfeld wanted a mechanical-looking effect, as if real, physical panels of the car were shifting to create this new form. "The vehicle doesn't really transform," Aron remarked, "it is just exposed. The car gets wider, for example, to compensate for the two enormous fuel-burning rockets on the back. I wanted to reveal that in a very ratchety, mechanical transformation."

Larry Tan built the Mercedes digital model geometry; but a severely compressed production schedule led to some unorthodox methods for completing the CG model. "We were running out of time," Aron recalled, "literally building the wings of the airplane as it was crashing! On top of that, our 3D painters were already log-jammed with work. One day during my lunch hour, I was



During the battle to retake MIB headquarters, Jay is attacked by Jarra, a bizarre floating alien who opens his flowing cloak to reveal a host of smaller clones, each in its own armed flying saucer. Jarra performer John Alexander was shot against bluescreen, his headtracked to digital models of a withered alien body and attached saucer. ILM animators treated the saucers as physical extensions of the characters, using kayaking as visual reference for the interaction between body and craft.

on the website of a national tire dealer, ordering racing tires for my motorcycle. Suddenly, a window popped up and asked ‘motorcycle or auto?’ And I thought, ‘Hmm, wait a minute...’ So I clicked ‘auto’ and there was a beautiful picture of a car tire. I thought: ‘This is great! Our model doesn’t have to go through 3D model paint at all!’ I dragged the image down, took it into Photoshop to modify it and duplicate it, and wrapped it around a little CG donut shape. And that gave us our tires for the car.”

Working with Larry Tan’s car geometry, Aron, Hirsh, and animators Maurice Bastian, Carlos Baena and Delio Tramontozzi began pushing and pulling on various parts of it to determine how that shape could transform into the supercar shape. “For instance,” said Aron, “the hood and quarter panels had to change shape, because the wings on the supercar had to come from somewhere. Everything on the car had to turn into something; and to do that we had to cut up the car.” Aron and his team broke the digital car into roughly 150 pieces, each animated to rise and turn until, eventually, an entirely new vehicle had been created. “The main thing was not to let any of the pieces stop. Everything was moving all the time.”

The two-shot transformation had been designed as a relatively compact effect to begin with — but as production progressed, the two shots were tightened further. The first, front-end shot, originally scheduled for 120 frames, was cut to only 51 frames; and the back-end shot — including the revelation of the supercar’s rocket cones — went from 170 to 40 frames. “We originally thought we’d be showing the transformation all the way to the completed car,” Aron said, “but we had to pull the plug on that idea when the shot lengths were cut. We were all heartbroken as we found out the new cuts were getting shorter and shorter, but we realized that Barry was right. All we had to tell the audience was that the car is transforming, and then — for lack of a better phrase — cut to the chase.”

The element of the car that caused the most grief for everyone involved was its rocket-thruster blast effects, which Sonnenfeld stated from the beginning should look exactly like those in the original film. All ILM had to do, Sonnenfeld said, was replicate that look. “I thought, ‘This is a no-brainer!’,” recalled Aron. “We’d used particles for the thruster on the first movie, which was really overkill because the thrusters are just cones, just geometry. So, this time, we went the geometry route, adding a shader we had used for the comet in *Deep Impact*. It looked beautiful and perfect — and exactly like the thruster in the first movie.” But when Sonnenfeld saw the thruster effects — both the ones from the original picture and the new replicas, side by side — he decided that, on second thought, he did not like the look of them. Nearly out of time, a team of computer graphics artists quickly developed an all-new look in the last week of production.



Racing to evade Serleena and deliver the Light of Zarthra to its departure point from earth, Jay pushes a button to transform his deluxe Mercedes-Benz into a flying supercar. Barry Sonnenfeld’s brief for the transformation effect was that it look like a physical, mechanical occurrence, rather than a too-clean digital morph. ILM animators broke a Mercedes digital model into 150 pieces, each animated to reposition until the new supercar form emerged.

That look continued to be refined during the compositing stage. “Among other things,” explained Greg Maloney, “Barry wanted them to have a heat ripple. He also wanted an enormous amount of cyan in them. Not blue — cyan. Barry loves that color, which is a green-blue. He also wanted an umbra of darker blue. Getting all of that looking just so was a big project.”

In addition to massaging the look of the thrusters, the compositors added bluescreen footage of the characters to the inside of the car — bluescreen footage that was less than satisfactory. “It was a difficult bluescreen,” explained Maloney, “because the actors were static. It wasn’t that the bluescreen was shot poorly; it was just that it was not a really good match for the action Barry wanted in the scene. So my compositor, Michael Kennedy, went in and did some 2D tricks to help sell that shot. He actually moved the characters’ heads in 2D and repositioned them inside the car.”

To capture aerial plates for the flying car sequence, production had put a camera on a crane in New York and flown it through the city streets.

Additional helicopter plates provided backgrounds for shots of the car flying over water. Those plates were then married to the airborne digital supercar, with reflections off the live-action buildings applied to the vehicle to integrate it into the scene. Additional compositing tricks helped guide the viewer’s eye to the car in a very busy wide shot of its emerging from Times Square. “This was a huge visual environment with lights and a black sky and neon signs,” stated Maloney, “so we had to do some tricks to make your eye go to that one car, such as amping up the blue thruster light in the back. We also had our roto paint artist, Jiri Jacknowitz, make it less busy by painting out numerous people in the crosswalks and other cars coming up the street.”

For the purposes of quick approvals, the revised city canyon plates were sent to the Sabre high-speed compositing group, which created precomps of the backgrounds and digital car. Once Sonnenfeld’s approval had been earned, bluescreen, live-action and digital elements for the air chase either stayed at ILM or went to Tippett Studio for final compositing.

In one ILM air chase composite over water, the supercar zooms by camera at screen left, followed by Serleena in her ship flying off-screen right, then reentering frame. Compositors had tried using available live-action footage of the water, Statue of Liberty and the New Jersey shoreline for the shot; but when those plates proved unsuitable, digital artists created a 3D matte painting of the Jersey shore, as well as 3D water that blended up to the water in the matte painting. All of Ellis Island and the Statue of Liberty were also created in 3D.

Jay steers the car into a tunnel, closely followed by Serleena in her ship. Backgrounds for the shots were captured in a New York subway tunnel, and served as the basis for complex



Men in Black II ends with the revelation that our entire world is contained within a single locker at an alien version of Grand Central Station. Rhythm & Hues supplied the closing shot, a continuous pullback that dollied from a live-action element of Will Smith and Tommy Lee Jones standing at a locker door set piece to an all-digital reveal of the vast station and its inhabitants. The company populated its CG set with about 120 computer animated aliens.

composites assembled at ILM. “We pulled the camera back in the plate,” said Greg Maloney, “skip-printed the footage, painted the track out, stabilized the plate and put in the ship — all in compositing.” Digital doubles occupied the car at the far end of the tunnel; but as it sped toward camera, the digital doubles transitioned into bluescreen photography of the actors — another trick executed by Michael Kennedy.

The chase ends when the Mercedes’ engine stalls, the car drops like a stone, and Serleena flies right into the open mouth of Jeff the Worm. Jay, Kay and Laura finally make it to the designated rooftop departure point, filmed on the Sony lot on a set featuring a glass skylight and a large boulder sculpture, all bordered with bluescreens into which the New York backgrounds would be composited. The backgrounds consisted of a series of matte paintings derived from photographic stills — a panorama that could be employed for any camera angle.

For a shot of Jeff the Worm — with Serleena inside — bursting through the skylight, production filmed a practical glass-breaking effect on the set. Jeff continues to rise through the rooftop, then explodes into a massive, horrific version of the tentacled Serleena monster. In terms of design, the huge rooftop creature was very similar to the neural root seen at the beginning of the film. “We wondered how we could make the same creature play at two completely different scales,” Mike Bauer. noted. “Just blowing up the little neural root would not have looked right. We had to figure out, what makes something look big? It turned out to be a matter of both texture and movement. Wetness also played a big part in making a creature of this size.” Animation lead Jennifer Emberly oversaw the employment of both procedural and hand-animation on the giant neural root. Sequence supervisor Kevin Reuter was the key look development person on the creature — both in its tiny and huge scales — and Russell Earl served as sequence supervisor for the rooftop. “It was a huge effort. At our peak, we had sixty technical directors working on it, thirty animators, and many, many compositors.”

The Serleena monster snatches Jay off his feet and flings him this way and that in her ubiquitous tentacles. The live-action for the sequence was achieved by suspending Smith in a gridwork of ropes over the rooftop set, and shooting him against bluescreen. “They hoisted Will Smith up on a rig and gave him some big foam hoses to fight with,” explained Tom Bertino. “He went through all the motions of struggling with the tentacles and being strangled by them. He was great — we got a lot of really good footage of him.”

Though Smith’s vigorous performance helped to sell the gag, it proved problematic for the roto department, which had to remove all of the ropes, targets and hoses in the live-action plate. “At one point,” recalled Katie Baird, “he wrapped this hose all around his arm and even bit it — but, somehow, we had to make that hose go away. Cameron Griffin completely rebuilt the lower half of Will Smith’s face for the biting. For other shots we had to rebuild arms and hands, finding a hand from another frame, cloning it, and then finessing it to make it look like a hand in that frame.”

Compositing supervisor Tom Rosseter assigned compositors Susan Weeks and Shawn Hillier to work out the final relationship of Will Smith and the monster. “The two of them did a great job of sorting out the depth, shadows, matting and color timing of the shots,” Rosseter said. “These were the kind of shots where 2D, 3D, paint and roto artists were all working together as parts of

a well-oiled machine.” Other shots of Jay’s struggle with the Serleena monster employed a digital double, built and animated from motion capture data derived when Smith’s stunt double went through a series of actions on ILM’s motion capture stage.

As Jay contends with the monster, the boulder transforms into Laura’s escape pod — a straightforward CG effect that masked the physical replacement of the sculpture with a set-piece pod, built by the prop department. ILM’s transition effect was a combination of Sabre 2D light effects and particle animation. “We also built a CG version of the pod,” said Mike Bauer, “for shots of its opening and closing. In those cases, we mapped photography of Laura onto a card and put that inside the digital pod.” Serleena is finally destroyed by MIB weapons fire as the escape pod lifts off, bound for Zartha, and fireworks fill the night sky. To ensure that the spectacle that has just played out is not remembered by the citizens of New York, the entire city is paralyzed by the Statue of Liberty’s torch.

“All of those shots — from the time they shoot the Serleena monster, through the successive shots of the Statue of Liberty and the fireworks over the city — are completely digital,” explained Bauer. “In order to get just the right composition, production decided to create the cityscape, the Statue of Liberty, the water around the Statue of Liberty, the paralyzer light and the fireworks all in CG.”

The entire rooftop sequence was deeply affected by the events of September 11, 2001. In the original version of the script, the World Trade Center towers played a central role, serving as giant paralyzers for the end gag, and as the site for the final confrontation with Serleena. But those story points and other already-filmed sequences had to be revised in the wake of the terrorist attack. The World Trade Center towers were prominently featured, for example, in shots of Ben’s Pizzeria in Soho. “In fact,” recalled John Berton, “one of the reasons production picked that location was that you could see the towers in the distance. It was a beautiful backdrop. But after September 11, we went in and did some paint work to remove the towers from that scene.”

Just as many opening sequences had been considered, the movie’s final scene at MIB headquarters went through a number of iterations, as well. In one, Jay’s despondency over losing Laura is eased a bit by the discovery that Frank the Pug is, beneath his dog suit, a beautiful singer/actress. In another version, Jay was going to be shrunk down in size, enabling him to vacation in Lockertown. Though production shot elements for these scenes, Sonnenfeld finally decided on an ending that starts with Jay and Kay, at headquarters, discussing the inhabitants of Lockertown.

“You’ve got to let those guys know there is a bigger world out there,” Jay says, “that there is more to life than living inside a locker.” Kay laughs and says, “Still a rookie,” then moves to a door with a big sign on it — EMERGENCY EXIT: DO NOT KICK OPEN — EVER! He kicks it open, revealing that our world is enclosed in one of thousands of lockers inside a giant alien Grand Central Station.

Rhythm & Hues took on the ending sequence, the only live-action element for which was a bluescreen shot of Tommy Lee Jones kicking open a prop door, with Will Smith standing in the near background. The camera move started on that element, then pulled back into Rhythm &

Hues' digital shot. "We took that dolly pullback plate and tracked the door so that we'd understand how the camera had moved on set," Bill Westenhofer said. "Then, midway through the pullback, our CG camera started to diverge from that."

Westenhofer's team built the alien Grand Central Station in CG, including a massive wall of lockers extending hundreds of feet high on either side and a polished marble floor, with some architecture implied in the reflections. "We talked about building kiosks and other structures," Westenhofer said, "but Barry wanted to keep it very simple. His aesthetic is very clean — almost like an Ikea aesthetic. He also wanted the lockers to be reflective; so instead of doing a matte painting, we built them in 3D."

The company then populated the CG set with approximately 120 alien characters, designed by Nick Pugh. "Out of forty designs," said Westenhofer, "Barry chose four. We modeled those and added some random variations in the sizes and colors so they wouldn't all look the same." Procedural walk cycles were developed for the aliens, with additional actions hand-animated.

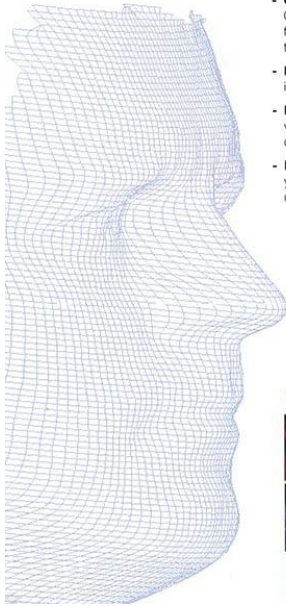
The Grand Central Station scene epitomized Barry Sonnenfeld's approach to *Men in Black II*'s humor, so well established in the first film. "The big thing in Barry's humor is the dryness," noted Tom Bertino. "His humor is all based on the incongruity of the situation. So all of these characters behave in a dead-serious manner. They behave as if they are not in on the joke. Aliens ordering Burger King, talking dogs, crawling artichokes — it's all just another day in the life. There are no winks to the camera."

With the Grand Central Station scene, *Men in Black II* comes to a close. Throughout the highly accelerated production schedule — with its unexpected changes due to world events and major redirections by Barry Sonnenfeld — the crews at Cinovation, ILM, Rhythm & Hues, Tippett Studio and Sony Pictures Imageworks showed a remarkable willingness and capacity to work together. Formal divisions between companies faded, as did divisions between departments within a single company. "There was a real heavyweight synergy between companies and departments on this show," John Berton reflected, "a lot of cross-pollination on many shots — but everything came together. There really wasn't a division. My hope was that the visual effects shots would be so seamless, you wouldn't be able to tell where one discipline left off and another picked up. That was the way the crew functioned on this show — and that was a delight."

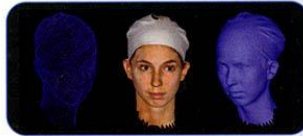
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